IBM System/3
Basic Assembler
Reference Manual

Program Numbers:
- 5702-AS1 (Models 8 and 10)
- 5704-AS1 (Model 15)
- 5704-AS2 (Model 15)
- 5705-AS1 (Model 12)

SC21-7509-7
File No. S3-21

Program Product

Preface

This publication is a reference manual for the programmer using the IBM System/3 Basic Assembler language. This language provides facilities for representing machine usable instructions symbolically on a one-for-one basis. The symbolic representations are translated by the IBM System/3 Basic Assembler into the machine usable form necessary for running a program on the System/3.

System/3 Model 8

The System/3 Model 8 is supported by System/3 Model 10 Disk System control programming and program products. The facilities described in this publication for the Model 10 are also applicable to the Model 8, although the Model 8 is not referenced. It should be noted that not all devices and features which are available on the Model 10 are available on the Model 8. Therefore, Model 8 users should be familiar with the contents of *IBM System/3 Model 8 Introduction*, GC21-5114.

Related Publications

The *IBM System/3 Models 8, 10, 12, and 15 Components Reference Manual*, GA21-9236, contains specifications governing the use of assembler language instructions.

Eighth Edition (April 1975)

This is a minor revision of SC21-7509-5 incorporating Technical Newsletters:

SN21-5385 March 17, 1976
SN21-5434 December 31, 1976
SN21-5536 June 24, 1977

This revision makes some changes to various pages and introduces information concerning the IBM System/3 Model 8. Changes to text and small changes to illustrations are indicated by a vertical line at the left of the change; new or extensively revised illustrations are denoted by the symbol ● at the left of the figure caption.

This edition applies to version 12, modification 00 of IBM System/3 Model 10 Disk System Basic Assembler (Program Product Number 5702-AS1); version 03, modification 00 of IBM System/3 Model 15 Basic Assembler (Program Product Number 5704-AS1); and to all subsequent versions and modifications unless otherwise indicated in new editions or technical newsletters. Changes are continually made to the specifications herein; before using this publication in connection with the operation of IBM Systems, consult the latest IBM System/3 Bibliography, GC20-8080, for the editions that are applicable and current.

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A Reader's Comment Form is at the back of this publication. If the form is gone, address your comments to IBM Corporation, Publications, Department 245, Rochester, Minnesota 55901.

Contents

The IBM System/3 Basic Assembler language is a symbolic language. That is, it must be translated into a form usable by the computer before a program can be run. The computer-usable form is called machine language, and the IBM System/3 Basic Assembler language provides a convenient method for representing, on a one-for-one basis, machine language instructions and related data necessary to write a program for IBM System/3. This one-for-one relationship to machine language instructions gives assembler language great programming versatility.

The assembler language is composed of symbols, called mnemonics, which are used to represent the operation codes of two types of instruction statements:

1. *Machine instruction statements* are the symbols that represent machine language instructions on a one-for-one basis. Note that symbolically represented machine instructions are *translated* into machine language by the assembler.

2. *Assembler instruction statements* are instructions which control the functions of the assembler. Each assembler instruction statement causes the assembler to perform a specific operation during the assembly process.

The IBM System/3 Basic Assembler:

- Processes instructions written in assembler language.
- Translates the assembler language instructions into machine language.
- Assigns storage locations.
- Performs other functions necessary to produce an executable machine language program.

In order to call the assembler from its storage location, a specific set of OCL (operation control language) instructions must be used. Following these OCL instructions, the user may elect to include an OPTIONS instruction, a facility which allows him to take advantage of various combinations of output listings and punched decks.

There are certain procedures for storing assembler routines on the Model 10 Disk System, Model 12, and Model 15 R (relocatable) Library and for loading assembler object programs into main storage. These procedures, as well as the other items mentioned briefly above, are discussed more fully in the text.

MINIMUM SYSTEM REQUIREMENTS

The minimum system configuration and optional device support for the Basic Assembler program is shown in the *IBM System/3 Models 6, 8, 10, and 12 System Generation Reference Manual,* GC21-5126 and in the *IBM System/3 Model 15 System Generation Reference Manual,* GC21-7616.

MAIN STORAGE REQUIREMENTS

The Model 10 Disk System Basic Assembler (5702-AS1) requires 8,192 bytes of main storage for execution, exclusive of control program requirements.

The Model 12 Basic Assembler (5705-AS1) and the Model 15 Basic Assembler (5704-AS1 or 5704-AS2) require 10,240 bytes of main storage for execution, exclusive of control program requirements.

The IBM System/3 Basic Assembler language is a symbolic language that provides a convenient method for representing, on a one-for-one basis, machine language instructions. The symbolic representations in assembler language coding are translated by the IBM System/3 Basic Assembler into the machine language form usable by the computer. In order to code in assembler language, the user must become familiar with certain terms, coding conventions, instructions, and other features of the language. The remainder of this chapter deals with these items.

BASIC STATEMENT FORMAT

A statement coded in assembler language can contain up to four entries from left to right: Name, Operation, Operand, and Remark. See *Assembler Coding Conventions* in this manual for an explanation of the contents and functions of each entry.

TERMS AND EXPRESSIONS

A term is a single symbol, self-defining value, or location counter reference which can be used only in the operand field of an assembler language instruction. The three types of terms are described under *Terms* in this section.

An expression consists of one or more terms. It is used to specify the operand fields of assembler language instructions. Terms and expressions are classed as either absolute or relocatable. A term or expression is absolute if its value is not changed when the assembled program in which it is used is relocated in main storage. A term or expression is relocatable if its value is changed when the program in which it is used is relocated.

Program relocation is the loading of an assembled program (object program) into a different area of main storage from that which was originally assigned by the assembler. The difference (in bytes) between the originally assigned address of the object program and the address of the relocated object program is the amount of relocation. The addresses assigned to all instructions and data in the relocated program are changed by the amount of relocation. In Figure 1, Object Program A is initially loaded at address 2000 in main storage. When Object Program A is loaded a second time, it is placed at address 3000 in main storage. The amount of relocation is 1000 bytes. Therefore, the values of all relocatable terms and expressions used in Object Program A would be increased by 1000 during the second loading.

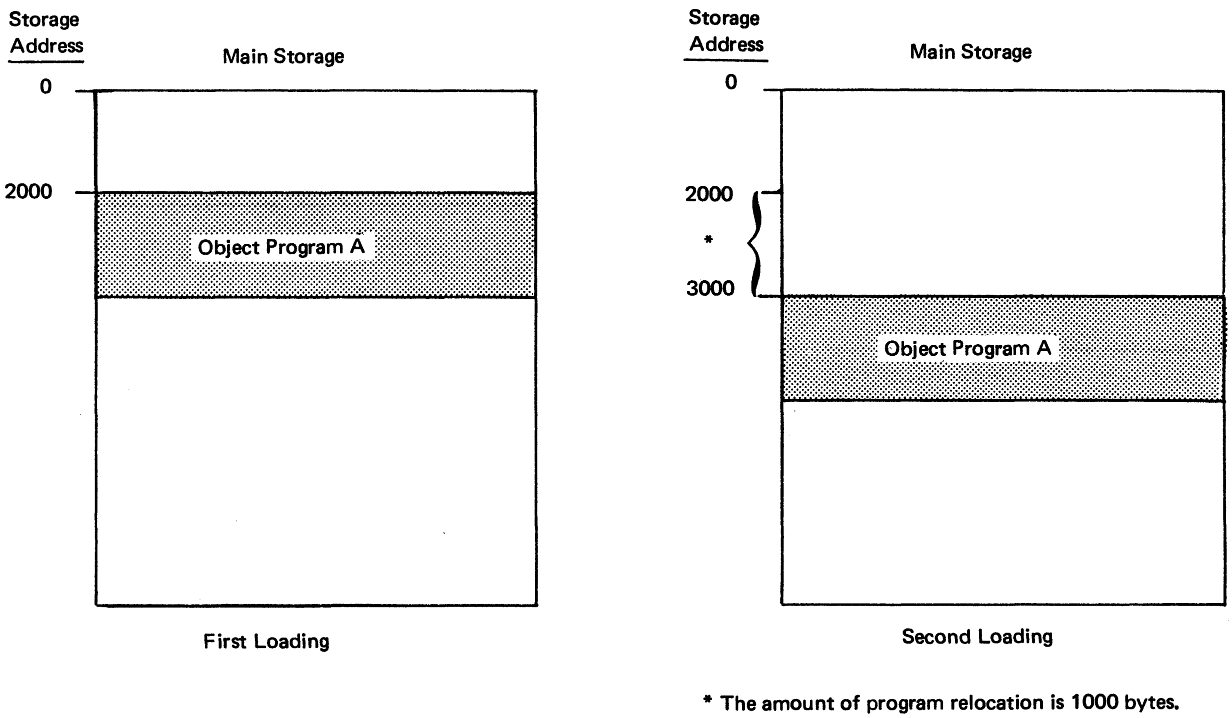


Figure 1. Program Relocation

TERMS

Three types of terms are used in the IBM System/3 Basic Assembler language.

- Symbol
- Self-defining term
- Location counter reference

The Symbol

A symbol is a character or combination of characters used to represent storage locations, instructions, input/output units, registers, or arbitrary values. A symbol can be used in either the name field or the operand field of a statement. When used in the name field, the symbol is called a name field entry. When used in the operand field, the symbol is called a symbolic term.

When the assembler finds a symbol in the name field of a statement, it assigns to that symbol an address value attribute. See *Addressing* in this section. The assembler also assigns a length attribute to the symbol, which is the number of bytes in the storage field named by the symbol. There are exceptions. When the assembler encounters EQU, START, or TITLE statements, it does not assign the usual attributes. EQU name field entries derive their values from the operand, START name field entries are assigned a length of 1, and TITLE name field entries are assigned no values at all.

The same symbol cannot be used as a name entry more than once within a program with the exception of the TITLE card. In order for a symbol to be used in the operand field, it must be defined (that is, used as a name) on an instruction other than a TITLE card somewhere in the program. Once it is defined, the symbol may appear in any number of operands. Whether the symbol is used as a name or an operand, these rules must be followed:

1. The symbol can consist of no more than six characters, the first of which must be either alphabetic or $, #, @. The other characters can be any combination of alphabetic, numeric, or $, #,@.
2. Blanks and special characters other than $, #, @ cannot be used in a symbol.

The Self-Defining Term

The self-defining term is a term which specifies an actual value or bit configuration.

The value expressed by the self-defining term is taken literally by the assembler and is assembled into the instruction. Like all terms, the self-defining term is used only in the operand field.

There are four types of self-defining terms:

- Decimal
- Hexadecimal
- Binary
- Character

Decimal Self-Defining Terms

A decimal self-defining term is an unsigned decimal number written as a sequence of decimal digits. High order zeros may be used, such as in 0003. If a decimal term is used as an address, its value cannot exceed the number of bytes in main storage. A decimal term consists of no more than five digits and cannot exceed a value of 65,535. This value is equivalent to the binary value that can be contained in two bytes. A decimal self-defining term is assembled as its binary equivalent.

Examples: 16 132 00006 43678

In the following example, a decimal self-defining term is used in a Move Immediate (MVI) instruction. The binary equivalent of 25 would be placed in the 1-byte area referenced by the symbol, COST

NAME	OPERATION	OPERAND
ALPHA	MVI	COST, 25

Hexadecimal Self-Defining Terms

Hexadecimal self-defining terms can consist of up to four hexadecimal digits enclosed in apostrophes and preceded by the letter X.

Examples: X'C34A' X'04F' X'6' X'DE'

Each digit is assembled into its 4-bit binary equivalent. Therefore, the maximum value would be X'FFFF' (65,535).

The following is an example of the use of a hexadecimal self-defining term. The 1-byte area at SWITCH would contain the hexadecimal value F0 (binary, 11110000) after execution of the instruction.

NAME	OPERATION	OPERAND
BETA	MVI	SWITCH, X'F0'

Binary Self-Defining Terms

Binary self-defining terms are written as a sequence of 1's and 0's enclosed in apostrophes and preceded by the letter B; such as B'1011'. This term would appear in storage as 00001011. The high-order (leftmost) bits are padded with 0-bits to make a multiple of eight bits of data (one or two bytes). A maximum of 16 bits of data can be represented in each term. In the following example of a Move Immediate instruction, the binary information will be moved into the 1-byte field at AREA.

NAME	OPERATION	OPERAND
GAMMA	MVI	AREA, B'10110011'

Character Self-Defining Terms

Character self-defining terms consist of one or two characters enclosed by apostrophes and preceded by the letter C; such as C'A3'. Any of the valid punch combinations can be used in a character self-defining term.

Examples: C'A9' C'EA' C'LB' C'3'

Because certain terms in the assembler language must be enclosed by apostrophes (such as C'EA'), for every apostrophe that is used as a character in a self-defining term, two must be written. For example, the characters A' would be written as C'A'''.

In the following example, a dollar sign ($) would be moved into the byte field at REPORT.

NAME	OPERATION	OPERAND
DELTA	MVI	REPORT, C'$'

Location Counter Reference

Location Counter: The location counter is an internal counter, maintained by the assembler, which always points to the next available storage location. As each new statement is processed, the location counter is increased by the number of bytes in the assembled statement. The assembler uses the current address in the location counter to assign consecutive storage addresses to program statements.

Location Counter Reference: A location counter reference is an asterisk (*) used as a term in the operand of an instruction. When the assembler encounters an asterisk, it substitutes the current value of the location counter (which always points to the next available storage location) for the asterisk.

EXPRESSIONS

An expression consists of an arithmetic combination of one or more terms. In a multi-term expression, terms must be separated by an arithmetic operator: the arithmetic operators are + for addition, – for subtraction, and * for multiplication.

Examples: AREA+X'2D' N–25 R+15 A*8

The rules for coding an expression are:

1. Two terms or two operators must not be used consecutively in an expression.

2. Parentheses cannot be used in an expression.

3. Only absolute terms can be used in a multiply operation.

4. Blanks are not allowed in an expression.

5. a. Using the Model 10 disk system basic assembler, an expression may consist of only one term when that term is a symbol used as the operand of an EXTRN statement.

   b. Using the Model 15 basic assembler, if the expression contains an external symbol, then the expression must be of the form A or A±e. A is a symbol used as the operand of an EXTRN statement and e is an absolute expression.

   Note: An A±e expression must not be in a Model 10 subroutine with RPG II.

If there is more than one term in the expression, the terms are reduced to a single value as follows:

1. Each term is evaluated separately.

2. Arithmetic operations are then performed in a left-to-right sequence, except that multiplication is performed before addition or subtraction. An example would be A+B*C, which would be evaluated as A+(B*C), not (A+B)*C. The result would be the value of the expression.

3. The intermediate result of the expression evaluation is a 3-byte, or 24-bit value. Intermediate results must be in the range of -2^{24} through $2^{24}-1$. Negative values are carried in the two's-complement form. The final value of the expression is the truncated, rightmost 16 bits of the result. The value of the expression before truncation must be in the range of -65536 through +65535. A negative result is considered to be a 2-byte positive value.

Note: In address constants the full 24-bit final expression result is truncated on the left to fit the length of the constant.

Absolute Expressions: An expression is considered absolute if its value is unaffected by program relocation.

An absolute term may be a non-relocatable symbol, or any of the self-defining terms. All arithmetic operations are permitted between absolute terms.

An absolute expression can contain relocatable terms or a combination of relocatable and absolute terms under the following conditions:

1. The expression must contain an even number of relocatable terms.

2. The relocatable terms must be paired and each pair must consist of terms with opposite signs. The paired terms need not be adjacent.

3. Relocatable terms cannot be used in a multiplication operation.

Pairing relocatable terms with opposite signs cancels the effect of the relocation, because both terms would be relocated by the same value. Therefore, the value represented by the paired terms would, in effect, remain constant regardless of the program relocation. For example, in the absolute expression A–Y+X, A is an absolute term and X and Y are relocatable terms. If A equals 50, Y equals 25, and X equals 10, the value of the expression would be 35. If X and Y are relocated by a factor of 100, their values would become 110 and 125, respectively. However, the expression would still evaluate as 35 (50–125+110=35). Absolute expressions reduce to a single absolute value.

Relocatable Expressions: A relocatable expression is one whose value changes by the amount of relocation when the program in which it is used is relocated. All relocatable expressions must reduce to a positive value.

A relocatable expression can be a combination of relocatable and absolute terms under the following conditions:

1. There must be an odd number of relocatable terms.

2. All relocatable terms, except one, must be paired and each pair must consist of terms with opposite signs. The paired terms need not be adjacent.

3. The unpaired term must not be immediately preceded by a minus sign.

4. Relocatable terms cannot enter into a multiplication operation.

All terms in a relocatable expression are reduced to a single value. This single value is the value of the unpaired relocatable term after it has been adjusted (displaced) by the resultant value of the other terms in that expression. For example, in the expression W–X+Y where W, X, and Y are relocatable terms; and W=10, X=3, Y=1; the result would be the relocatable value of 8.

If the program is relocated by 100 bytes, the resultant value of the expression would be increased by the amount of relocation (100), giving the expression a value of 108.

In the following expression, a combination of absolute and relocatable terms are used: A+F*G–D+B. A, D, and B are relocatable terms; F and G are absolute terms. When given the values A=3, B=2, D=5, F=1, and G=4, the result would be a relocatable value of 4. The multiplication occurred first, resulting in 4; then the addition and subtraction of the other terms, including the result of the multiplication, was performed in a left-to-right direction. The result of the arithmetic operations is a relocatable value of 4 for this expression.

Upon relocation, the value of this expression can be determined by adding the amount of relocation to all relocatable terms.

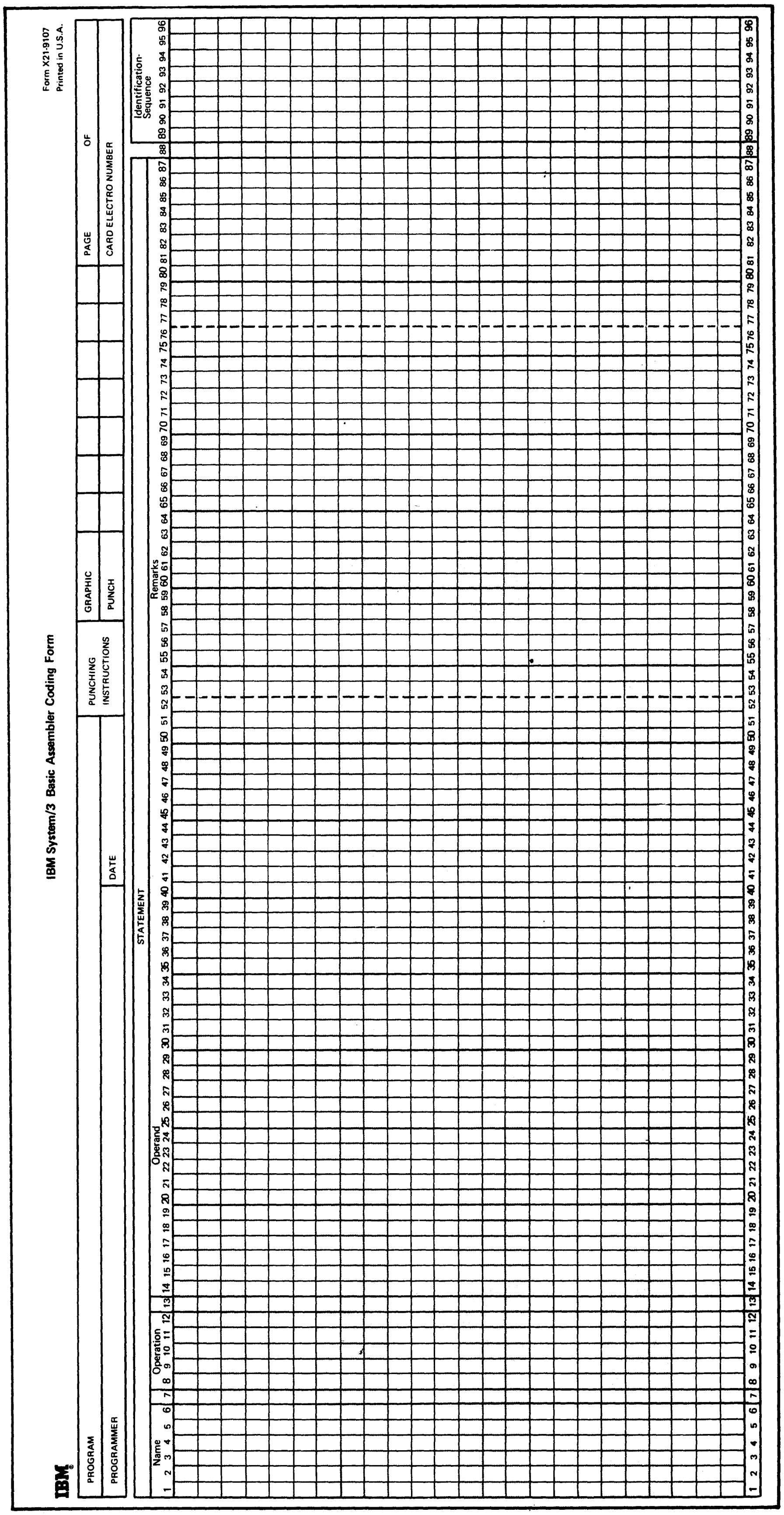
ASSEMBLER CODING CONVENTIONS

This section explains the general coding conventions associated with the IBM System/3 Basic Assembler language. When coding in assembler language, the programmer uses the IBM System/3 Assembler Coding Form (Figure 2).

The Statement Format

Each line on the coding form is divided into two segments: Statement (columns 1-87), and Sequence (columns 89-96).

The Statement segment can contain up to four entries, from left to right: Name, Operation, Operand and Remark. The Name field is column dependent. It must start in column 1, unless otherwise specified by the ICTL assembler instruction (see *Assembler Instruction Statements*). All other entries can start in any column, as long as there is at least one blank separating each entry and the entries remain in the stated order. Figure 3 is a diagram of assembler statement entries.



ART: 52908

Figure 2. IBM System/3 Basic Assembler Coding Form

Name Entry

- Optional or required depending on the specific instruction.
- Up to six characters can be used in a name.
- First character must be alphabetic (including $, #, @).
- First character must be in column 1 unless otherwise specified by an ICTL assembler instruction.
- No special characters or blanks in a name (except $, #, @).
- At least one blank must follow the Name entry or appear in the first Name entry column (if no name is entered).

Operation Entry

- Required entry.
- Contains mnemonic operation code (list of valid machine codes is in *Appendix A. Machine Instructions).*
- Must be followed by a blank.

Operand Entry

- Optional or required depending on the specific instruction.
- Contains coding that describes data to be acted upon.
- Operands are separated by a comma.
- No blanks between terms or operands.
- Blanks are allowed within character constants and character self-defining terms only.
- If the entire operand entry is omitted, but a remark entry is desired, absence of the operand must be indicated by a comma in the operand entry, preceded and followed by one or more blanks.
- Must be followed by a blank.

Remark Entry

- Optional entry.
- Contains a brief verbal description of the statement's function.
- Cannot extend beyond column 87 or a limit prescribed by ICTL assembler instruction.
- Can contain any combination of valid characters or blanks.
- Must be followed by a blank.

Identification–Sequence Entry

- Optional entry.
- Contains statement identification or sequence characters.
- See *ISEQ – Input Sequence Checking* later in this section.

Comment Statements

The entire statement field (columns 1-87) can be used for comments by placing an asterisk in column 1 (or the beginning column, as set by the ICTL assembler instruction). Comments can be extended for more than one line by the repeated use of the asterisk in the first column of additional cards. Comment lines may be used anywhere in the source program and are printed on the program listing. Sequence checking is also performed on cards containing comment statements.

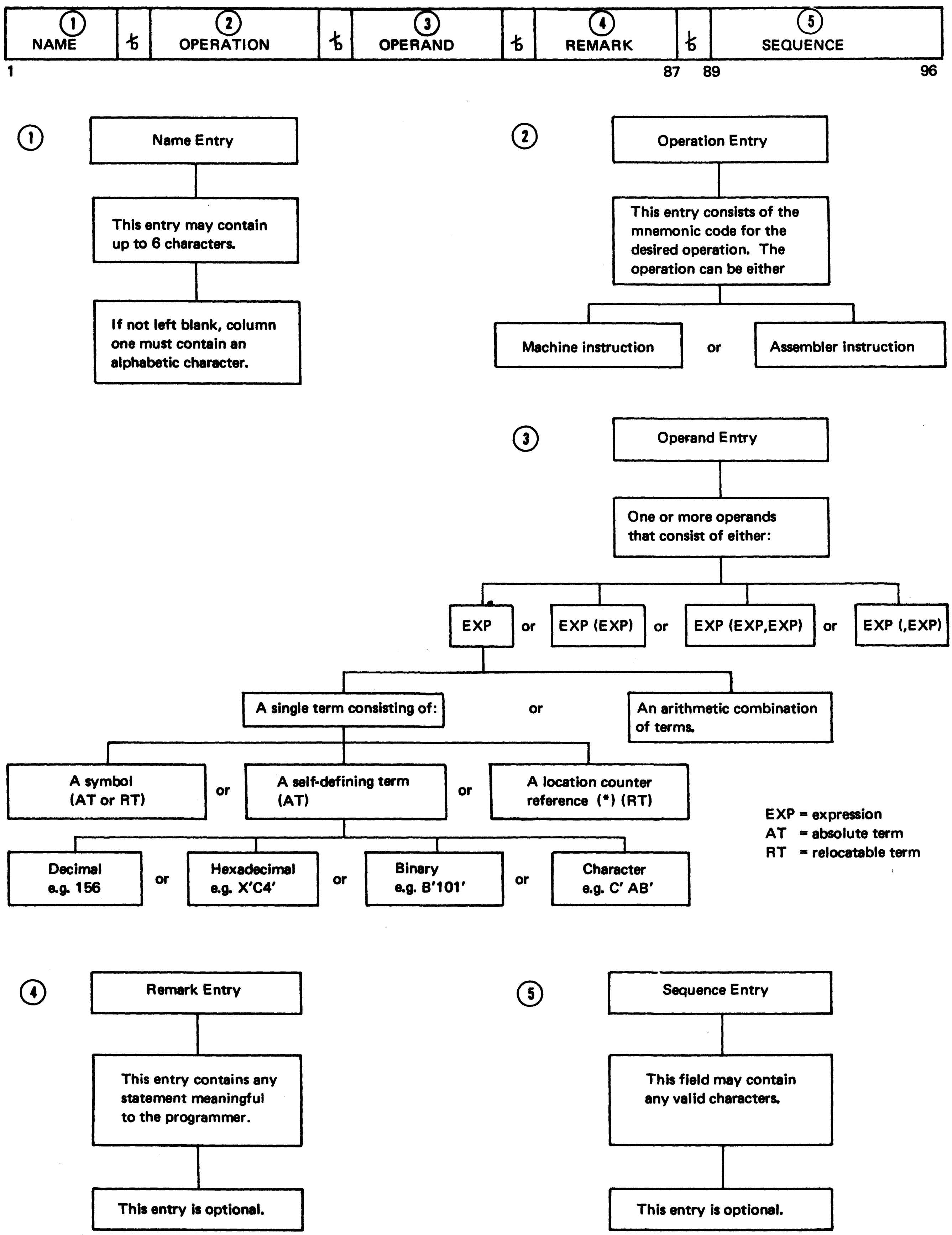


Figure 3. Assembler Statement Entries

ADDRESSING

The programmer must be able to access any part of storage. IBM System/3 provides two methods of addressing: direct and base-register displacement. The relative addressing technique can be used with both methods. For addressing, see the *IBM System/3 Models 8, 10, 12, and 15 Components Reference Manual*, GA21-9236.

Direct Addressing

The direct addressing method allows the programmer to represent a 16-bit instruction address by using an expression as an operand entry. The assembler places the value of the expression in the machine instruction which it generates.

Two bytes are always used in the machine instruction for a direct address. A direct address is indicated by the absence of a register in the operand.

Example: MVI A,C'D'

This indicates to the assembler that a direct address is to be generated for location A (see *Machine Instruction Operands).*

Base-Register Displacement Addressing

Base-register displacement addressing involves setting up a base address from which other addresses can be calculated. This base address must be placed in the base register before the base register is used for addressing.

One byte is always used in the machine instruction for a base-register displacement address and is indicated by the presence of a register in the operand.

Examples: MVI A(,2),C'D'
MVI 5(,1),C'D'

This indicates to the assembler that a base-register displacement address is to be generated for location A using base register 2 and for displacement 5 from base register 1.

IBM

PROGRAM

PROGRAMMER

```
Name    Operation  Operand
RX1     EQU        1
        LA         ADBASE,RX1
        USING      ADBASE,RX1
        MVC        A(,RX1),B(2,RX1)
         :
         :
```

Figure 4. Base-Register Displacement Addressing

The base register plus a displacement can reference any higher address within 255 bytes of the specified base address. The displacement portion of the address can be either absolute or relocatable; however, in either case the programmer indicates that a base-displacement address is to be generated by the presence of the register in the operand (see *Machine Instruction Operands*). If relocatable displacements are used, the USING statement (see *Assembler Instruction Statements*) must be used to indicate to the assembler which register contains the base address and what address will be loaded into that register. The USING instruction does not load the register with the specified address; the programmer must use a load instruction to place the indicated address into the register. Figure 4 is an example of base-register displacement addressing.

In Figure 4 two bytes of data will be moved from the location of B to the location of A. The assembler calculates the displacement to the addresses for A and B, if A and B are relocatable and are within a positive 255 bytes of the address in base register XR1. If either A or B is over 255 bytes from the base address, an addressing error occurs and an assembler error statement is generated. If the terms A and B are not relocatable symbols, the assembler uses the absolute values (up to 255) of the terms for the displacement. If absolute displacements are used, the USING assembler statement is not required.

Note: The programmer must explicitly specify the base register whenever base-register displacement addressing is used.

The programmer terminates the use of a previously defined base register through the use of the DROP instruction (see *Assembler Instruction Statements*). The value of the register is not affected. This register cannot, however, enter into base-register displacement addressing using relocatable displacements until specified again by a USING instruction.

Relative Addressing

Relative addressing is an addressing technique accomplished by adding bytes to or subtracting bytes from a symbol or location counter reference. The expression *+5, for example, specifies the location 5 bytes beyond the current value of the location counter. Figure 5 is an example of relative addressing.

In Figure 5, the instruction with the operation code ZAZ has a length of 6 bytes, the instruction AZ has a length of 5 bytes and the instruction with MVI has a length of 4 bytes in storage. Using relative addressing, the location of the AZ instruction can be expressed in two ways, AAA+6 or BBB–5.

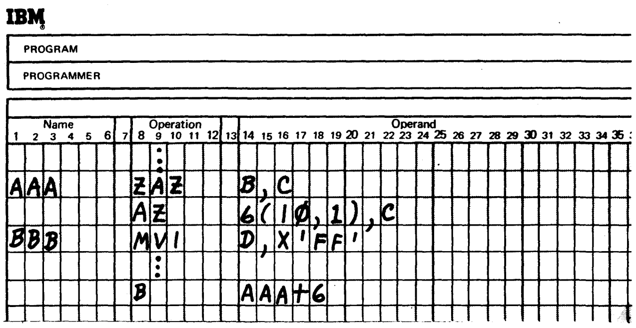


Figure 5. Relative Addressing

Figure 6 shows how the AZ instruction can be addressed relative to the nearby symbolic addresses, AAA and BBB.

Relative addressing may also be used with base-register displacement addressing if the displacement is a relocatable term.

Example: MVC A+5(,RX1),B(2,RX1)

In the example, A+5 is an example of relative addressing used with base-register displacement addressing.

Instruction Addressing

A symbol used as a name entry in a machine-instruction statement addresses the *leftmost* byte of storage occupied by that instruction.

Data Addressing

A symbol used as a name entry in a data definition instruction (see *DC – Define Constant* and *DS – Define Storage*) address the *rightmost* byte of storage occupied by or reserved for that data.

Control of Location Counter

Addressing in any computer language depends upon the location counter. IBM System/3 allows the programmer to control the location counter by using two assembler instructions: START and ORG. The START assembler instruction can be used to initialize the location counter to a desired value at the beginning of a program. The ORG assembler instruction can be used to change the value of the location counter anywhere in a program.

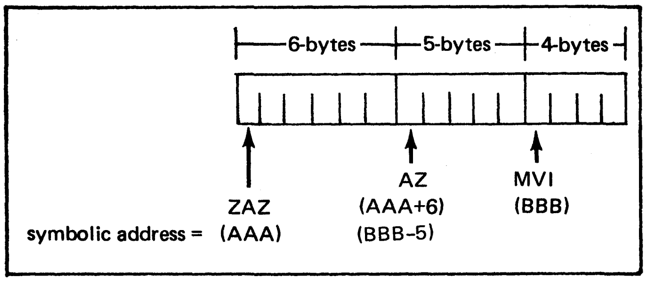


Figure 6. Schematic of Relative Addressing

These two instructions are described in detail under *Assembler Instruction Statements.*

MACHINE INSTRUCTION STATEMENTS

Machine instruction statements are symbols that represent machine language instructions on a one-for-one basis. The assembler translates these symbolic representations into machine language usable by the computer. Machine instruction statements differ from assembler instruction statements in that the machine instruction statements are executable parts of the program's logic (such as MVI, ST, LA, etc), while assembler instruction statements are simply orders to the assembler, each statement directing a specific operation (such as DC, START, SPACE, etc). See *IBM System/3 Models 8, 10, 12, and 15 Components Reference Manual,* GA21-9236 for a description of the execution of machine instructions.

The format for a machine instruction statement is closely related to, but not the same as, the machine language instruction format which results from the assembly process (see *Appendix A. Machine Instructions* for machine language instruction formats).

A mnemonic operation code is used in place of the actual machine language operation code and one or more operands provide the information required by the machine instruction. A remark and a sequence entry may be included in the machine-instruction statements, but they will not affect the machine language instruction.

Name Entry Attributes

Any machine-instruction statement can contain a symbol as a name entry. Other machine-instruction statements can use that symbol as an operand. The assembler assigns value and length attributes (characteristics) to every sumbol used in a program. The value attribute of a symbol which is used as a name entry in a machine-instruction statement is the address of the leftmost byte of storage occupied by the assembled instruction. The length attribute of the symbol is the number of bytes of storage occupied by the assembled instruction. Refer to *Lengths–Explicit and Implied* in this section for a discussion of the length attributes of other types of symbols, terms, and expressions.

Machine Instruction Mnemonic Codes

The mnemonic operation codes are designed to be easily-remembered codes that remind the programmer of the functions performed by the instructions. The mnemonic codes are translated into machine-language operation codes by the assembler. IBM System/3 Basic Assembler provides mnemonic and extended mnemonic operation codes. The complete set of mnemonic codes is listed in *Appendix A. Machine Instructions.*

Extended Mnemonic Codes

Extended mnemonic codes are provided for the convenience of the programmer. They are unlike other mnemonic codes in that part of the information usually provided in the operand is in the extended mnemonic code itself. Extended mnemonic codes allow the following:

1. Conditional branches (BC) and jumps (JC) can be specified mnemonically, requiring only a branch address as an operand.

2. Half-byte moves (MVX) can be specified mnemonically, requiring only the use of addresses as operands.

3. The supervisor call form of the command CPU (CCP) machine operation can be specified mnemonically (Model 15 only).

Extended mnemonic codes are not part of the set of machine instructions, but are translated by the assembler into the corresponding operation code and condition combinations.

See *Appendix A. Machine Instructions* for a list of extended mnemonic codes.

Machine Instruction Operands

This section describes (1) operand fields and subfields, (2) explicit and implied lengths, and (3) operand groups and formats. The operands of machine instruction statements provide the information about addresses, lengths, and immediate data that is required by the assembler to generate executable machine instructions. General rules for coding of operands are covered in *Assembler Coding Conventions.*

Operand Fields and Subfields

The left operand of a pair is called operand 1, or operand field 1; the right operand is called operand 2, or operand field 2. An operand field may include one or two subfields (length subfield, register subfield) as in the following example of base-register displacement addressing.

Example: 40(,2)

The above operand field contains a displacement entry, 40, and a register subfield entry, 2, representing index register 2. The following rules apply to the coding of subfields:

1. Parentheses must enclose a subfield or subfields.

2. Blanks cannot be used within subfield parentheses.

3. A comma must separate two subfields within parentheses (L,R).

4. If the first subfield of a pair is omitted, the comma that separates it from the second subfield must be retained (,R).

5. If the second subfield of a pair is omitted, the comma separating the pair must also be omitted (L).

6. If both subfields are omitted, the separating comma and the parentheses must also be omitted.

Operand subfields can contain immediate data, length, or register information. Only absolute expressions and self-defining terms may be used as subfield entries.

Lengths – Explicit and Implied

A length subfield in an operand may be either explicit or implied. To imply a length, the programmer omits the length subfield from an operand. When a length specification is not included in an operand requiring a length, the assembler includes the implied length of the first operand, such as the length attribute of a name entry (see *Name Entry Attributes* in this section). The length attributes of various terms and expressions are shown in Figure 7.

An explicit length is written by the programmer in the operand as an absolute expression. The explicit length overrides any implied length.

Term or Expression	Length Attribute
1. Name entry symbol of a machine-instruction	Length, in bytes, of the instruction.
2. Location-counter reference (*)	Length, in bytes, of the instruction in which it appears (except in the EQU assembler statement, where the length attribute assigned is one).
3. Expression	Length attribute of the leftmost term in the expression.
4. Self-Defining Term	Length attribute is one.
5. START name entry	Length attribute is one.

NOTE: See also *Subfield 3 -- Length* under *Data Defining Instructions.*

Figure 7. Length Attributes of Terms and Expressions

Operand Groups

Machine-instruction statement operands are divided into six groups. The characteristics of each group are as follows:

Group 1: Two-operand format in which a length is explicit or implied in both operands.

Group 2: Two-operand format in which a length can be explicit in either operand, but not in both. If length is not explicit in either operand, the assembler uses the implied length of operand 1.

Group 3: Two-operand format in which a length cannot be specified.

Group 4: One-operand format in which only immediate data may be used.

Group 5: Two-operand format in which both operands are immediate data.

Group 6: Two-operand format in which operand 1 is used by the assembler to calculate a positive displacement and operand 2 is immediate data.

Figure 8 shows the allowable operand formats for each operand group. The instructions using each operand group are also listed. Refer to *Appendix A. Machine Instructions* for the related machine-instruction formats.

For the extended mnemonics of the MVX instruction, the I-field information is inherent in the mnemonic and the I-field is omitted from the operand. For the extended mnemonics of the BC and JC instructions, the second operand (I-field) is not used since the information is inherent in the mnemonic (see *Extended Mnemonic Codes* in this section).

Data movement is from operand 2 to operand 1 in a two-address format instruction (group 1 and group 2). This operand order is equivalent to that of machine instructions.

GROUP	INSTRUCTIONS	ALLOWABLE OPERAND FORMAT			
1	ZAZ,AZ,SZ	A,A	A(L),A	D(,R),A	D(L,R),A
		A,A(L)	A(L),A(L)	D(,R),A(L)	D(L,R),A(L)
		A,D(,R)	A(L),D(,R)	D(,R),D(,R)	D(L,R),D(,R)
		A,D(L,R)	A(L),D(L,R)	D(,R),D(L,R)	D(L,R),D(L,R)
2	MVC,CLC,ALC	A,A	A(L),A	D(,R),A	D(L,R),A
	SLC,ITC,ED	A,A(L)	A(L),D(,R)	D(,R),A(L)	D(L,R),D(,R)
		A,D(,R)		D(,R),D(,R)	
		A,D(L,R)		D(,R),D(L,R)	
	MVX	A,A(I)	A(I),A	D(,R),A(I)	D(I,R),A
		A,D(I,R)	A(I),D(,R)	D(,R),D(I,R)	D(I,R),D(,R)
3	MVI,CLI,SBN	A,I		D(,R),I	
	SBF,TBN,TBF				
	TIO,SNS,LIO				
	BC				
	L,ST,A,LA	A,R		D(,R),R	
	SCP*,LCP*				
4	APL,SVC*	I			
5	HPL,SIO,CCP*	I,I			
6	JC	A,I			

*Model 15 only.

The following codes are used to describe the possible operand formats:

CODE	MEANING	ACCEPTABLE FORM
A	Address	Relocatable expression, absolute expression, or self-defining value.
D	Displacement	Relocatable expression, absolute expression, or self-defining value.
L	Length	Absolute expression or self-defining value.
R	Register	Absolute expression or self-defining value.
I	Immediate Data (bit masks, condition bit masks, or control bits to be used in the instruction)	Absolute expression or self-defining value.

Figure 8. Operand Format by Group

In groups 3, 5, and 6, the Q-code operand is always on the right. See *Appendix A. Machine Instructions* for an explanation of Q codes.

ASSEMBLER INSTRUCTION STATEMENTS

When writing a program the programmer uses two types of statements: executable instructions and instruction statements to the assembler. The executable instructions are the machine instruction statements. These are symbolic representations of the programmer's logic, such as branch, move, or compare, which are translated into machine language by the assembler.

Assembler instruction statements, on the other hand, do not generate executable machine codes. They are instructions that control specific assembler functions. These instructions are used to set up areas in storage, to define data, to equate symbols, and to control program listings, location counter, statement formats, and types of addressing. In the remainder of this section, the individual assembler instruction statements are discussed.

Symbol Definition Instruction

EQU—Equate Symbol

The EQU instruction is used to equate symbols with register numbers, immediate data, or other arbitrary values. The EQU instruction defines a symbol by assigning to it the length and value of the expression in the operand field of the EQU instruction. The EQU instruction has the following format:

NAME	OPERATION	OPERAND
symbol	EQU	an expression

The expression in the operand field can be either absolute or relocatable. Any symbol appearing in the operand field must have been previously defined. Figure 9 illustrates how this instruction can be used to equate a symbol with the contents of the operand.

In Figure 9, MAX has the value of TEST + X'3FC' (X'102+X'3FC' or X'4FE') any time it is used in the program. The symbol STEST has the value of the first (left most) byte of the data area reserved by the DC instruction. Since the symbol on the DC (TEST) has the value of the rightmost byte, this type of EQU is useful for addressing the leftmost byte. The symbol REG2 in any statement is the same as using the number 2.

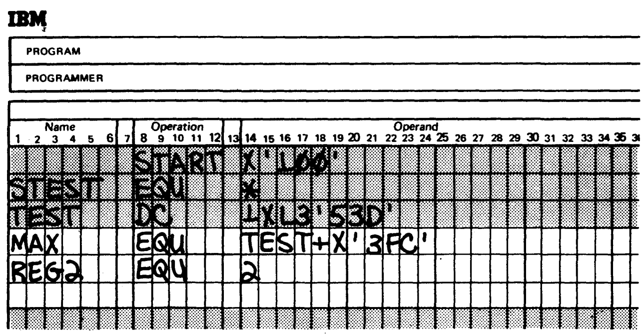


Figure 9. EQU Assembler Instruction

Data Defining Instructions

Two data defining instruction statements are available: Define Constant (DC), and Define Storage (DS). These instructions are used to enter data constants and to reserve areas in storage. Each instruction can have a name field entry (symbol) to which other instructions can refer.

DC—Define Constant

The DC instruction is used to initialize a storage location with a desired value. The IBM System/3 Basic Assembler Language allows six types of constants: storage address, binary, character, decimal, hexadecimal, and integer. The format of the DC instruction is as follows:

NAME	OPERATION	OPERAND			
symbol or blank	DC	Duplication Factor (1)	Type (2)	Length (3)	Constant (4)

Notice that the operand of the DC statement consists of four subfields. The first three describe the constant and the fourth provides the constant. The only blanks permitted within an operand field are blanks embedded in a character constant. The symbol that identifies the DC statement receives the value of the address of the *rightmost* byte of the area defined by the statement.

Subfield 1–Duplication Factor: This subfield enables the programmer to repeat the constant in storage. The constant will be generated the number of times indicated by the entry in the first subfield. This entry can be any unsigned, nonzero, decimal value, 1 through 65535. If this subfield is omitted, a duplication factor of 1 is assumed. This duplication factor is applied after the constant is fully assembled. If duplication is specified for an address constant containing a positive location counter reference, the value of the location counter used in each duplication is increased by the length of the constant.

Subfield 2–Type: This subfield defines the form of the constant being entered. From the type specification, the assembler determines how it is to interpret the constant and translate it into the appropriate machine format. The type entry is specified by one of the letter codes A, B, C, D, X, or I (see *Subfield 4 – Constant* for related meanings). *The type entry is required.*

Subfield 3–Length: The third subfield describes the number of bytes required by the constant. The entry for this subfield may be written two ways:

1. Ln, where n is an unsigned, nonzero, decimal value. The value of n is as follows:

   n = 1-256 for I, B, C, X constants

   n = 1-31 for the D constant

   n = 1-3 for an A constant

2. L (absolute expression), where an absolute expression is enclosed in parentheses. The value limits for the absolute expression are the same as those for n in the previous paragraph. A location counter reference is not allowed in this expression.

The total area allocated for this constant is the result of: Duplication Factor * Length=Total Area. *The length entry is required.*

Subfield 4–Constant: This subfield supplies the constant that was described in subfields 1 through 3. In general, the address constant (type A) is enclosed in parentheses, while the data constants (types B, C, D, I, and X) are enclosed in apostrophes. *An entry in the constant subfield of a DC statement is always required.*

Address Constant (A): This constant is used to load an address into a storage area.

Example: SYMBOL DC AL2 (BETA)

In this example, the address represented by the symbol BETA will be stored in the 2-byte field addressed by SYMBOL. The full 24-bit final expression result is truncated on the left to fit the length of the constant. The maximum length of an address constant is 3.

Binary Constant (B): This constant is used to create bit patterns and masks.

Example: SYMBOL DC 1BL1'10011'

The byte of storage addressed by SYMBOL will contain 00010011. Truncation or padding with binary zeros occurs on the left if the constant is not the length specified. This constant is enclosed in apostrophes. Each digit within the apostrophes represents a single bit in storage, and each eight bits specified will occupy one byte of storage.

Character Constant (C): This constant can be used to place a string of characters in storage.

Example: SYMBOL DC 1CL17'PLANT 5 PAYROLL'

The byte of storage addressed by SYMBOL will contain a blank, and the byte of storage addressed by SYMBOL-16 will contain the character P.

Note: Two blanks have been padded on the right of the character string.

If the constant is not the specified length, truncation or padding with blanks will occur on the right. Each character (including blanks) within the apostrophes will occupy a byte of storage. If an apostrophe occurs within the string of characters, it must be represented by a double apostrophe.

Decimal Constant (D): This constant can be used for arithmetic purposes.

Example: SYMBOL DC DL5'125.66'

This constant will appear in zoned-decimal form in a 5-byte storage field, addressed by SYMBOL. The decimal point is used only as a convenience for the programmer, and is *not* assembled into the constant. The value of the constant is calculated without the decimal point. Truncation or padding with decimal zeros occurs at the left of the field, if necessary. Signed decimal constants are permitted, making it possible to have a decimal constant with a negative value. Each decimal digit will occupy one byte of storage.

Hexadecimal Constant (X): This constant is used to associate a hexadecimal value with a symbol in a defined area in storage.

Example: SYMBOL DC 1XL6'8AC14'

The 6-byte field addressed by SYMBOL will contain the following 12 hexadecimal digits: 00000008AC14.

Truncation or padding with hexadecimal zeros occurs at the left. Each two digits between apostrophes will occupy one byte of storage.

Integer Constant (I): This constant is used for fixed-point binary arithmetic.

Example: SYMBOL DC 1IL2'-7'

A negative number may be used for an I constant. The negative constant is placed in storage in its two's-complement form. This example would appear in storage in bit form as 1111111111111001. There is always a positive equivalent to a negative constant; in the above example, it is hexadecimal FFF9 or decimal 65,529. The range of I constants must be within $-2^{32}+1$ to $2^{32}-1$. If the number is positive, it is padded on the left with 0-bits. If the number is negative, it is padded on the left with 1-bits.

DS–Defines Storage

The DS instruction is much like the DC instruction. It assigns a symbol to an area of storage. Unlike the DC instruction, the DS instruction only reserves the area of storage, it does not insert data. A constant subfield cannot be used with a DS statement. The following illustration shows the DS format.

NAME	OPERATION	OPERAND		
symbol or blank	DS	duplication factor	type	length

A duplication factor of zero can be used in a DS statement if the programmer wishes only to assign a length to its corresponding symbol. The symbol will be given the value of the current location counter minus one. The type and length subfields must follow the same rules as for the DC statement.

The duplication factor can be used by the programmer to specify a reserved area larger than 256 bytes.

Example: SYMBOL DS 3CL100

This instruction would reserve a 300-byte area, which would be referenced on the right by the name entry SYMBOL.

Listing Control Instructions

The listing control instructions aid the programmer in documenting his assembler listing. These instructions are TITLE, EJECT, SPACE, and PRINT.

TITLE – Identify Assembly Output

The TITLE instruction enables the programmer to identify assembled object cards and assembler listings.

NAME	OPERATION	OPERAND
label or blank	TITLE	a sequence of characters enclosed in apostrophes

The name field entry can consist of a maximum of six characters. The first character may be numeric. The contents of the name field in the first TITLE card is punched into the sequence field of all object cards produced by the assembler. This name field entry also appears in all listing header fields.

The name on the TITLE statement is not the object program name, but may be the same as the object program name. See *START – Start Assembly.* The name field entry is used only for identification and may not be referenced by the program.

The operand field contains a sequence of characters enclosed in apostrophes. Any embedded apostrophes must be represented by a double apostrophe. The contents of the name and operand fields are printed at the top of each page of the assembler listing.

A program can contain more than one TITLE statement. When a new TITLE statement is read, the listing is advanced to a new page before the new heading is printed. The name fields of all subsequent TITLE statements are ignored by the assembler. The TITLE instruction is not listed on the assembler listing, but it does increase the statement counter by one. Figure 10 shows an example of the TITLE statement.

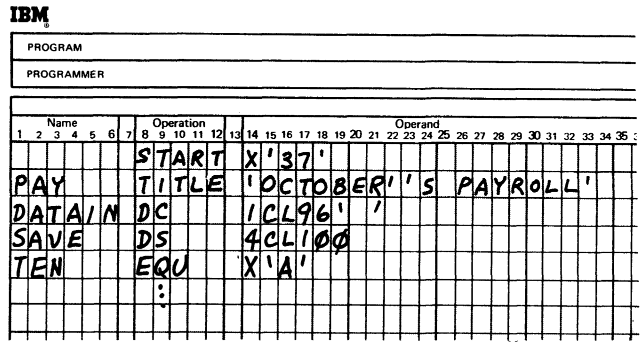


Figure 10. Use of the TITLE Statement

EJECT – Start New Page

The EJECT instruction causes printing to begin at the top of a new page, under the page heading. Through the use of the EJECT statement, the programmer can separate routines in the assembler listing. The format of the EJECT assembler instructions is as follows:

NAME	OPERATION	OPERAND
blank	EJECT	Not Used

In Figure 11, the EJECT instruction is used to separate executable instructions from the data-defining assembler statements. The EJECT instruction is not listed on the assembler listing, but it does increase the statement counter by one. The coding example in Figure 11 shows the position of EJECT. Note that the corresponding statement number (4) has been omitted in the listing. Statement number 5 appears at the top of the next page, under the heading.

SPACE – Space Listing

This instruction is used to insert one or more blank lines between statements in the assembler listing:

NAME	OPERATION	OPERAND
blank	SPACE	decimal value or a blank

An unsigned decimal value is used to specify the number of blank lines that are to be inserted. If the operand contains a blank, a zero, or a 1, one blank line will be inserted. If the value of the operand exceeds the number of lines remaining on the current page, the instruction has the same effect on the listing as an EJECT statement. The SPACE instruction, like the EJECT instruction, is not listed on the assembler listing, but does increase the statement counter by one.

IBM System/3 Basic Assembler Coding Form

PROGRAM PROGRAM 1
PROGRAMMER XXX
DATE
PUNCHING INSTRUCTIONS GRAPHIC PUNCH

```
PROG1   START X'1ØØ'
MASK1   DC    1BL1'Ø11Ø1'
COUNT3  DC    3IL2'Ø'
        EJECT
READ    LIO   ........
STORE   MVC   ........
          :
        END   READ
```

Listing Page 1

Statement number	Name	Operation	Operand	Remark
1	PROG1	START	X'100'	
2	MASK1	DC	1BL1'01101'	
3	COUNT3	DC	3IL2'0'	

Listing Page 2

Statement number	Name	Operation	Operand	Remark
5	READ	LIO	....	
6	STORE	MVC	....	
		.		
		.		
		.		
		END	READ	

Figure 11. EJECT Instruction

PRINT—Print Optional Data

The programmer can control the printing of an assembly listing by using the PRINT instruction. A program can have any number of PRINT instructions. Each PRINT instruction controls the listing until the next PRINT instruction is encountered.

NAME	OPERATION	OPERAND
blank	PRINT	operand

The operand field can include entries from the following groups (one or two operands for the Model 10, one, two, or three operands for the Model 12 and the Model 15):

1. ON—A listing is printed.
   OFF—No listing is printed.

2. DATA—Constants are printed out in full on the assembler listing.
   NODATA—Only the leftmost 8 bytes of the constants are printed on the assembler listing.

3. (Model 12 and Model 15 only)
   GEN—Print statements generated by the macro processor if not overridden by other listing control statements.
   NOGEN—Suppress printing of statements generated by the macro processor.

Operand entries must be separated by a comma.

The ON, GEN and DATA conditions are assumed by the assembler unless otherwise specified by a PRINT instruction. If an operand is omitted, it is assumed to be unchanged and continues according to its last specification. Both of the examples in Figure 12 would cause a listing to be printed with only the leftmost 8 bytes of the constants appearing in the listing.

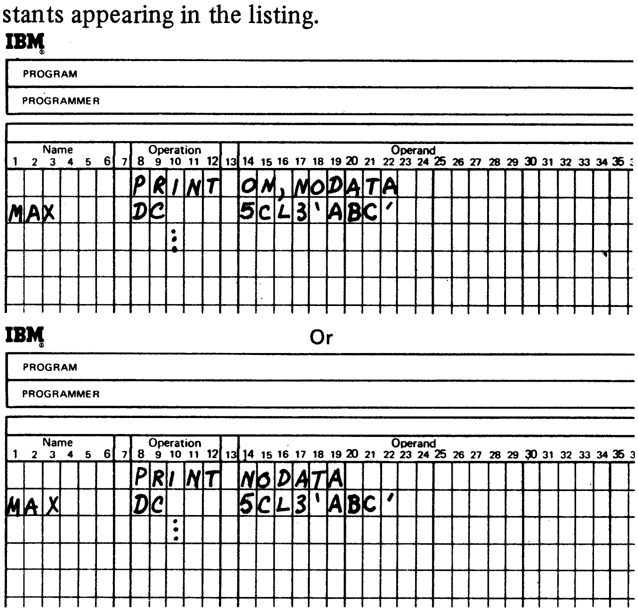


Figure 12. The PRINT Statement

Program Control Instructions

ICTL—Input Format Control

The ICTL statement permits the programmer to change the normal bounds of the source program statements. When included, the ICTL instruction must precede all other source statements. This instruction can be used only once during a program. An invalid or mispositioned ICTL statement causes termination of the assembly.

NAME	OPERATION	OPERAND
blank	ICTL	two decimals in the form of B,E

The term B specifies the beginning column and the term E specifies the ending column of the source statement. The beginning column must be within columns 1-48. The ending column must be within columns 49-95. The column after the ending column must be blank.

When an ICTL statement is not included in a source program, the beginning column is assumed to be column 1, and column 87 is assumed to be the ending column. Figure 13 is an example of the ICTL instruction. In Figure 13, the name field would start in column 14 and the remark field would end in column 80.

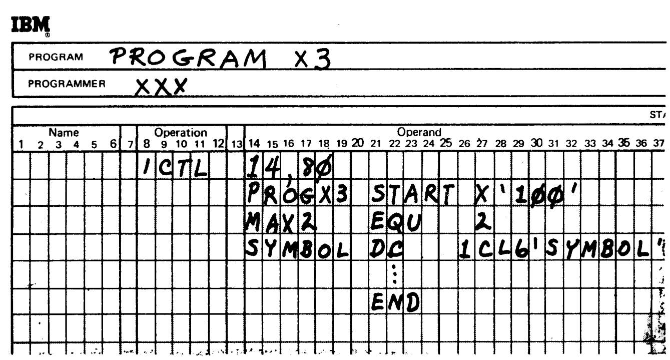


Figure 13. The ICTL Statement

ISEQ—Input Sequence Checking

The ISEQ instruction is used to check the sequence of source cards. Sequence checking begins with the first card after the ISEQ instruction. The first sequence entry is taken from the sequence identification field of the ISEQ statement. The sequence entry on the next card is then compared to the previous sequence value. The ISEQ assembler statement has the following effect:

1. The sequence entries on source-statement cards are checked for ascending order.

2. Statements that are out of order and statements without sequence entries are flagged in the assembler listing.

3. The total number of flagged statements is noted at the end of the assembler listing.

For example, with the sequence values 13, 27, 31, 6, 8, 45, 47, ƀ and 48, the card numbered 6 and the card without a sequence value would be out of sequence. The assembly does not stop due to a card being out of sequence order. In this example, the card numbered 6 and the card without a sequence entry would be flagged in the error field of the listing. If sequence checking is requested, there is a statement at the end of the listing showing that two cards were out of sequence.

The assembler will not check the sequence unless requested to do so by use of the ISEQ statement.

The following is the ISEQ instruction format:

NAME	OPERATION	OPERAND
blank	ISEQ	two decimal values in the form L, R; or blank

The operand entries, L or R, specify the leftmost (L) and rightmost (R) columns of the field to be sequence checked. The value of L must be within the range of 73 through 96 (inclusive). The length of the sequence field may be from 1 to 8. If the programmer wants to discontinue sequencing, an ISEQ instruction card with a blank operand is inserted.

The sequence field must be separated from the last column of the source statement by at least one blank position. The last column of the source statement is column 87 unless otherwise specified by the ICTL assembler statement. The sequence field must not appear before the last column +1 of the source statement. If the sequence field is to start before column 89, the ICTL statement must be used to redefine the beginning and end of the source statement. For example:

ICTL	1, 71	Source statement is defined within columns 1-71
ISEQ	73, 80	Sequence field is in columns 73-80

START–Start Assembly.

The START instruction may be used to initialize the location counter to a desired value at the beginning of a program. The format of the START instruction is:

NAME	OPERATION	OPERAND
symbol	START	a self-defining value or blank

The assembler uses the single self-defining term in the operand as the initial location-counter value. For example, either of the START instructions in Figure 14 could be used to indicate an initial assembly location of 2040.

If the operand of a START instruction is blank, the location counter is initialized with a value of zero. If neither an ORG nor a START instruction is used to initialize the location counter, the initial value is also zero.

A START instruction must not be preceded by any statement that affects or is dependent upon the setting of the location counter.

The name entry in the name field of a START instruction provides the program with an identifier name called the module name. The module name may be the same as the first TITLE statement.

Note: Certain naming restrictions apply when assigning names for your program. For more information on naming restrictions, see *IBM System/3 Model 10 Disk System Control Programming Reference Manual,* GC21-7512, *IBM System/3 Model 12 System Control Programming Reference Manual,* GC21-5130, *IBM System/3 Model 15 System Control Programming Reference Manual,* GC21-5077 (Program Number 5704-AS1), or *IBM System/3 Model 15 System Control Programming Concepts and Reference Manual,* GC21-5162 (Program Number 5704-AS2).

This program name may be used for program linkage. If the START card is not included in the program, or if the name field is blank, a default program name is assigned. See the MODULE NAME MISSING diagnostic in *Appendix C. System/3 Assembler – Source Language Error Codes and Diagnostics.*

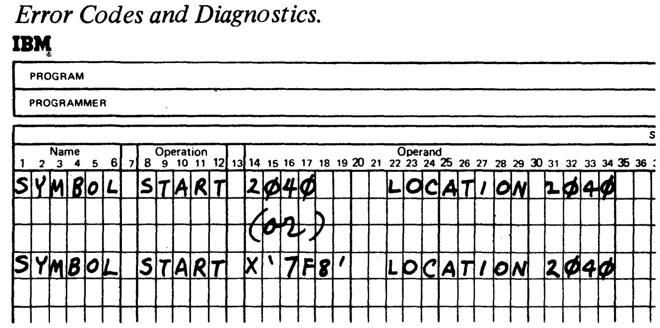


Figure 14. Using START to Initialize the Location Counter

ORG—Set Location Counter

The ORG statement sets the location-counter value.

NAME	OPERATION	OPERAND
blank	ORG	blank operand or an expression A optionally followed by two absolute expressions in the form A, B, C

The location counter is set to the smallest value greater than or equal to A which is C more than a multiple of B. In the following example, A can be either a relocatable or absolute expression; B and C must be absolute expressions. The default values for B and C are 1 and 0, respectively. If the second operand (B) is omitted, the third operand (C) must also be omitted.

Current Location Counter	A	B	C	*New Location Counter*
275	*	100	50	350
340	*	100	50	350
350	*	100	50	350
504	*	256	0	512
750	1000	—	—	1000

All symbols used in the expression A must have been previously defined. The value specified by the ORG statement must be greater than or equal to the starting location-counter value.

If previous ORG statements have reduced the location-counter value for the purpose of redefining the current program, an ORG instruction with a blank operand is used to set the location counter to the previous maximum assigned address plus one (see Figure 15).

Location Counter	Address	Name (1–6)	Operation (8–12)	Operand (14–)
0064		PROG4	START	1ØØ
0064	0069	SYMBOL	DC	1CL6' '
006A	*0325	FILLIN	DS	7CL1ØØ
00CE			ORG	FILLIN-599
00CE	01F9	DATA	DC	15ØCL2'AZ'
0326			ORG	
			:	
			END	

* Previous High Address

Figure 15. Using ORG to Control the Location Counter

USING — Use Register for Base-Displacement Addressing

The USING statement specifies the register to be used for base-displacement addressing and also specifies the base address that the assembler will assume to be in that register at object time. The USING statement does not load the base address into the register specified. This must be done by the programmer before the register can be used for base-register displacement addressing. See *Addressing* in this section.

NAME	OPERATION	OPERAND
blank	USING	V,R

In the preceding format, term V represents an expression. Term R represents an absolute expression with a value of 1 or 2. Term R specifies the index register assumed to contain the base address represented by the term V. The programmer has the option of changing the base register or base address at any time by the insertion of another USING statement. Two USING statements enable the programmer to use the two index registers as base registers to two different portions of main storage.

In Figure 16, register 2 is loaded with the address of ADRES1, which will be used as the base address in instructions following the USING statement.

IBM

PROGRAM

PROGRAMMER

Name (1–6)	Operation (8–12)	Operand (14–)
PROG1	START	
	:	
	LA	ADRES1,2
	USING	ADRES1,2
	:	
	:	

Figure 16. Specifying a Base Register With the USING Statements

DROP — Drop Base Register

The DROP instruction specifies a base register that is no longer to be used as a base register. The programmer can reinitiate the base register with another USING instruction.

NAME	OPERATION	OPERAND
blank	DROP	specified register

The operand must contain an absolute expression of either 1 or 2. This absolute expression represents the register that is no longer to be used as a base register. The contents of the register are unaffected by the DROP instruction. Figure 17 shows an example of the DROP instruction. Another USING statement is used to specify register 1 as the new base register.

IBM

PROGRAM

PROGRAMMER

```
PROG1  START
         :
       LA     ADRES1,2
       USING  ADRES1,2
         :
       DROP   2
       LA     ADRES2,1
       USING  ADRES2,1
```

Figure 17. Example of the DROP Statement

ENTRY — Identify Entry Point to Program

This instruction identifies symbols, defined in the current program, which can be used as entry points from other programs.

NAME	OPERATION	OPERAND
blank	ENTRY	any relocatable symbol found in the name field of the current program

The symbol used in the ENTRY operand can also be referenced by any other program provided that program uses the same symbol in the operand of an EXTRN statement. See the example given in the discussion of EXTRN for additional information on the use of ENTRY.

EXTRN — Identify External Symbols

This instruction identifies symbols, used in the current program, which are defined in another program. Each symbol in the operand of an EXTRN statement must be identified by an ENTRY statement or be the module name in some other program.

NAME	OPERATION	OPERAND
blank	EXTRN	one relocatable symbol not found in the name field of the current program, optionally followed by an absolute expression in parentheses

The external symbol cannot be used in a Name field in the same program that describes that symbol as an EXTRN.

An EXTRN subtype can be specified for the EXTRN symbol by following the symbol with an absolute expression enclosed in parentheses. The value of the absolute expression cannot be less than zero nor more than 255. Any symbol in the expression must have been previously defined. For an explanation of the subtype values and their meanings, see *IBM System/3 Overlay Linkage Editor Reference Manual,* GC21-7561.

Figure 18 shows how ENTRY and EXTRN can be used to make two or more programs act as one main program through sharing data and control. The main program defines symbols A, B, and C and identifies them as entry points. These same symbols are identified as EXTRNs (external symbols) in the subroutine. This allows the subroutine to use these symbols just as it would if the symbols had been defined in the subroutine. SUBR01, on the other hand, is defined and identified as an entry point by the subroutine and as an EXTRN, external symbol, by the main routine. These four symbols – A, B, C, and SUBR01 – can now be used interchangeably by both the main routine and the subroutine.

The main routine has control first. It executes instructions and then branches to SUBR01 which is defined as an entry point in the subroutine. Instructions in the subroutine are executed. Notice that the subroutine uses symbols A, B, and C which were defined in the main routine. Control is then passed back to the main routine.

Note: The actual resolution of symbols between programs is not performed by the assembler.

Main Routine

```
MAIN    START  Ø
        ENTRY  A
        ENTRY  B
        ENTRY  C
        EXTRN  SUBRØ1
ENTRY   EQU    *
        B      SUBRØ1
A       DC     DL4'1234'
B       DC     DL4'5678'
C       DS     CL5
        END    ENTRY
```

Subroutine

```
SUBR    START  Ø
        ENTRY  SUBRØ1
        EXTRN  A
        EXTRN  B
        EXTRN  C
SUBRØ1  ST     RETURN+3,B
        MVC    EDIT(5),MASK
        ZAZ    D(4),A(4)
        AZ     D(4),B(4)
        ED     EDIT(5),D
        MVC    C(5),EDIT
RETURN  B      Ø
MASK    DC     XL5'2Ø2Ø2Ø4B2Ø'
EDIT    DS     DL5
D       DS     DL4
        END
```

Figure 18. Example of ENTRY and EXTRN Statements

END–End Assembly

The END instruction terminates assembly of the program. The operand of this instruction can contain an expression (usually a name field entry) which specifies the address to which control is to be transferred after the program is loaded. The END instruction must be the last statement in the program. The relocatable expression in the operand must not contain external symbols. The start-of-control address must be specified for programs loaded with the absolute loader.

NAME	OPERATION	OPERAND
blank	END	a relocatable expression or a blank

Figure 19. shows an END statement. In this example, the program receives control at the address corresponding to BEGIN when it is executed.

PROGRAM: PROGRAM ONE
PROGRAMMER: XXX

```
PROG1   START
   .
BEGIN   MVC    OUT,ABC(1)
          :
        END    BEGIN
```

Figure 19. Designating an Entry Point With the END Statement

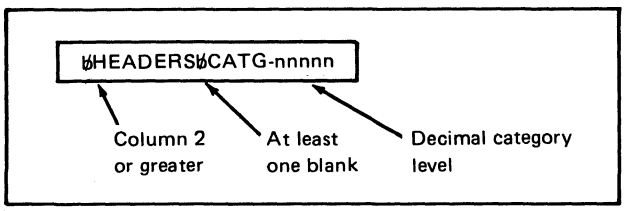
ASSEMBLER CONTROL STATEMENTS

Two control statements are used: The HEADERS statement and the OPTIONS statement. Up to 45 of these control statements may be used, in any order. Each statement is limited to six operands. All control statements must appear before any assembler source statements.

HEADERS Statement

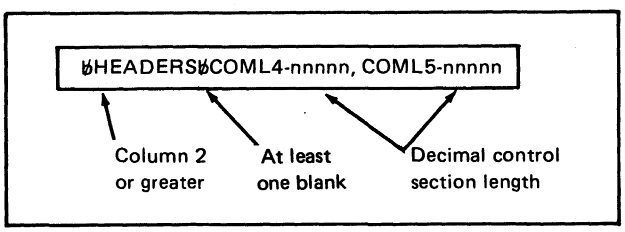
The HEADERS control statement specifies control information other than output control information to the assembler. The programmer may specify a category level for the object module through the CATG operand, or the length of the control section for any subtype 4 or 5 EXTRNs in the assembler through the COML4 and COML5 operands. For an explanation of category levels and subtype 4 and 5 EXTRNs, see *IBM System/3 Overlay Linkage Editor Reference Manual,* GC21-7561.

The format of the HEADERS statement with the CATG operand is:



nnnnn
nnnnn is a one to five character decimal string whose value must be less than 00256. If more than one CATG operand appears in the assembler control statements, the value of the last valid operand is used for the module category level. The module category level is placed in the module ESL record.

The format of the HEADERS statement with the COML4 and COML5 operands is:

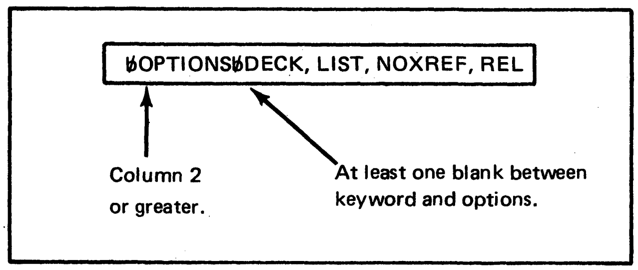


nnnnn is a one to five character decimal string whose value must be less than 65536. If more than one COML4 or COML5 operand is present in the assembler control statements, the length in the last valid operand is used for the appropriate subtype control section length. The lengths specified are placed in the ESL records for the subtype 4 or 5 EXTRNs.

OPTIONS Statement

An OPTIONS statement is a control statement for assembler control options. All OPTIONS statements must precede the source deck. The user may specify the following assembler options on OPTIONS statements: DECK, NODECK, LIST, NOLIST, XREF, NOXREF, REL, NOREL, OBJ, OBJ(T), OBJ(P), NOOBJ. XBUF-nnnnn and NOXBUF are also available to users having program 5704-AS2. They may appear on one statement in any order, but must be separated by commas. If the programmer prefers, separate statements may be used for each option. The OPTIONS keyword must start in column 2 or higher (the preceding column must be blank), and there must be one or more blanks between the keyword and the selected options. Blanks are not allowed between the selected options.

The following example shows options appearing on one statement:



More than one OPTIONS statement may be used. In the following example, three statements are used:

ƀOPTIONSƀDECK
ƀOPTIONSƀLIST
ƀOPTIONSƀNOXREF

The following list provides a brief description of all the options available:

Option	*Explanation*
DECK	The object program is punched. When an object program is punched, it is preceded by a // COPY OCL card and followed by a // CEND OCL card. These cards are provided for placing the object program in the R library with the library maintenance utility program ($MAINT).
NODECK	The object program is not punched.
LIST	The following sections of the assembler listing are printed (see *Assembler Listing* in this section for a description of the listings): • Options information • External symbol list • Source and object program listing • Diagnostic listing • Error summary statements
NOLIST	Only the following listings are printed: • Options information • Any statements in error and the associated diagnostics • Error summary statements The NOLIST option overrides all assembler PRINT statements.
XREF	A cross-reference listing is generated.
NOXREF	A cross-reference listing is not generated.
REL	A relocatable object program is produced.
NOREL	An absolute object program is produced. *Note:* Absolute object programs can only be used as stand-alone programs; that is, programs which are not dependent on any other disk management system program. On the Model 10 an absolute loader will precede the absolute deck if DECK is specified and if MFCU2 is specified on the // PUNCH statement. On the Model 12 and Model 15, an absolute loader will precede the absolute deck if DECK is specified and if the SYSPCH device is MFCU, 1442, or MFCM (Model 15 only). The loader punched will program load only on the device type on which it was punched. A blank card is inserted between the absolute loader and the object program. This blank card and the OCL cards included with the object program do not affect the operation of the absolute loader and may be discarded. To prevent cataloging of the absolute object program when NOREL is specified, you should specify NOOBJ.
OBJ or OBJ(T)	The object program is placed in the R library with a retain entry of temporary.
OBJ(P)	The object program is placed in the R library with a retain entry of permanent.
NOOBJ	The object program is not placed in the R library. (See *Placing Assembler Subroutines in R [Routine] Library* in this section.)

If no OPTIONS statement is used, the assembly is processed as though DECK, LIST, REL, XREF, and OBJ had been specified. NOXBUF is also assumed with program 5704-AS2.

XBUF-nnnnn	Specifies the size of the disk external buffers the user has requested. From one to five numeric digits may be used to specify the size of the disk external buffers (program 5704-AS2 only). External buffers should not be specified due to performance considerations if the program size including physical disk buffers does not exceed 56K. However, if external buffers are specified, they should equal the size of the physical disk buffers that normally would be set aside within the program.
NOXBUF	Specifies no external buffers are requested for the program (program 5704-AS2 only).

If DECK or OBJ is entered on the OPTIONS statement and there are errors in the assembly, a halt is issued.

OCL STATEMENTS FOR ASSEMBLER

The loading and running of a disk-system program, including the assembler, is done under control of a group of programs called *disk system management.* The user tells disk system management to run a program through the use of Operation Control Language (OCL) statements. It is necessary to have a set of OCL statements each time a program is run. This section discusses the OCL statements required for use of the assembler. For a complete discussion of OCL, see *IBM System/3 Model 10 Disk System Control Programming Reference Manual;* GC21-7512, *IBM System/3 Model 12 System Control Programming Reference Manual,* GC21-5130, *IBM System/3 Model 15 System Control Programming Reference Manual,* GC21-5077 (Program Number 5704-AS1), or *IBM System/3 Model 15 System Control Programming Concepts and Reference Manual* (Program Number 5704-AS2), GC21-5162.

The assembler language source program can be obtained from either a system input device, a source library entry, or the macro processor. If the source records are obtained from an 80-column device, they are padded with 16 blanks before being placed in the $SOURCE file. In this case, the user should provide an ICTL statement to prevent the assembler from processing the sequence field of the 80-column record.

OCL For Loading the Assembler

Source Program on System Input Device (Cards)

Figure 20 is a sample set of OCL statements to load the assembler when the source program is on cards. The unit parameter (F1) on the // LOAD statement specifies where the assembler resides. The codes for the disk drive upon which the assembler resides are:

- R1 – drive 1
- F1 – drive 1
- R2 – drive 2
- F2 – drive 2

The first // FILE statement specifies the attributes and location of the file used for source program residence during the assembly process.

The second // FILE statement specifies attributes and the location of the file used for object output of the assembler. The third // FILE statement specifies attributes and location of the file used for assembler working storage during the assembler process.

The $WORK2 // FILE statement is optional on the Model 10 Disk System. If it is not supplied, the assembler allocates the work space. However, by specifying the proper placement of file locations, as in Figure 20, this file statement improves the performance of the assembler. It should, therefore, be specified.

In all three // FILE statements, the PACK and UNIT parameters indicate the location of the file named in the NAME Parameter. In addition to R1, F1, R2, and F2, the UNIT parameter can specify D1, D2, D3, and D4 for the Model 15. The RETAIN parameter should reflect a scratch file(s). The TRACKS parameter contains the number of tracks required for that file. The user should choose the number of tracks required in accordance with the space requirements charts in the *Assembly Time Data File Requirements* section. See *IBM System/3 Model 10 Disk System Control Programming Reference Manual,* GC21-7512, *IBM System/3 Model 12 System Control Programming Reference Manual,* GC21-5130, and *IBM System/3 Model 15 System Control Programming Reference Manual* (Program Number 5704-AS1), GC21-5077, or *IBM System/3 Model 15 System Control Programming Concepts and Reference Manual,* GC21-5162, (Program Number 5704-AS2) for further information.

Source Program in a Source Library

Figure 21 shows a sample set of OCL statements used when the source program is in the source library.

IBM System/3 Basic Assembler Coding Form

```
/&
// LOAD $ASSEM F1
// FILE NAME-$SOURCE,PACK-VOLØØ1,UNIT-F1,RETAIN-S,
// TRACKS-25,LOCATION-2ØØ
// FILE NAME-$WORK,PACK-VOLØØ2,UNIT-R1,RETAIN-S,
// TRACKS-5,LOCATION-2ØØ
// FILE NAME-$WORK2,PACK-VOLØØ3,UNIT-F2,RETAIN-S,  (1)
// TRACKS-25,LOCATION-1ØØ
// RUN
     }
     Source Program Deck
     }
/*
/&
```

(1) Optional on Model 10 Disk System

Figure 20. Assembler OCL Statements (Source Program on Cards)

IBM System/3 Basic Assembler Coding Form

```
/&
// LOAD $ASSEM,R1
// FILE NAME-$SOURCE,PACK-VOLØØ1,UNIT-F1,RETAIN-S,
// TRACKS-25,LOCATION-2ØØ
// FILE NAME-$WORK,PACK-VOLØØ2,UNIT-R1,RETAIN-S,
// TRACKS-5,LOCATION-2ØØ
// FILE NAME-$WORK2,PACK-VOLØØ3,UNIT-F2,RETAIN-S,  (1)
// TRACKS-25,LOCATION-1ØØ
// COMPILE OBJECT-R1,SOURCE-SUBRA,UNIT-R1   <-- Place object program in R library on R1
// PUNCH MFCU2   <-- Punch Deck on MFCU
// RUN
/&
Source program in Source Library with: OPTIONS DECK, OBJ
```

(1) Optional on Model 10 Disk System

Figure 21. Assembler OCL Statements (Source Program in Source Library)

Note that the additional OCL statement // COMPILE is required. The following entries in the figure are optional:

PUNCH — This statement specifies where an object deck is punched. For more information on statement, see *IBM System/3 Model 10 Disk System Control Programming Reference Manual,* GC21-7512, *IBM System/3 Model 12 System Control Programming Reference Manual,* GC21-5130, *IBM System/3 Model 15 System Control Programming Reference Manual,* GC21-5077 (Program Number 5704-AS1), or *IBM System/3 Model 15 System Control Programming Concepts and Reference Manual,* (Program Number 5704-AS2), GC21-5162.

OBJECT operand — This operand is used to indicate to the assembler the library unit used when the OBJ option is used on the OPTIONS statement.

The // LOAD and // FILE statements are as described in the first example. The // COMPILE statement specifies both the location of the source library and the required source program within the library. The // COMPILE statement may appear at any position between // LOAD and // RUN.

Macro Processor-Produced Source Program

The macro processor creates a source program on the $SOURCE file. To indicate that the macro processer has already loaded the $SOURCE file, external indicator U1 must be turned on. This is done through a // SWITCH statement. If this indicator is on when the assembler is loaded, the $SOURCE file will not be loaded.

In the following OCL stream, the source program has been created on the $SOURCE file:

```
//  LOAD $ASSEM,R1
//  SWITCH 1XXXXXXX
//  FILE NAME-$SOURCE,...
//  FILE NAME-$WORK,...
//  FILE NAME-$WORK2,... (1)
//  RUN
```

Indicate that the source file has been loaded by the macro processor step. (points to the // SWITCH statement)

References the source file created by the macro processor step. (points to the // FILE NAME-$SOURCE statement)

(1) Optional on Model 10 Disk System

Note: For more information on the macro processor, see *IBM System/3 Models 10 and 12 System Control Programming Macros Reference Manual,* GC21-7562, or *IBM System/3 Model 15 System Control Programming Macros Reference Manual,* GC21-7608.

// SWITCH Considerations

The external indicator U1 indicates that the macro processor has loaded the $SOURCE file and the source program is not in the input stream. If this indicator is on when the assembler is loaded, the $SOURCE file is not loaded.

When the $SOURCE file is to be loaded, external indicator U1 must be off. This can be ensured by entering the following statement after the assembler // LOAD statement:

```
//  SWITCH øXXXXXXX
```

OCL For Calling the Assembler

It is possible for the user to store a portion of the OCL statements required for use by the assembler in a procedure library. They may then be called with a // CALL statement, thus reducing the number of written OCL statements required for each assembly. Examples are included for source programs on cards and for source programs in a source library on disk.

Source Program on Cards

If the source program is a deck of cards, the OCL cards necessary to assemble the program, and the order in which they must appear, are as follows:

```
//  CALL ASM,F1
//  RUN
    Source Program Deck
/*
```

In this example, ASM is the procedure name. F1 refers to the disk pack upon which the assembler OCL procedure is stored. In this case, it would be the fixed disk on drive one.

Source Program in a Source Library

If the source program is stored on disk in a source library, the OCL format must be as follows:

```
// CALL ASM,F1
// COMPILE SOURCE-SUBRA,UNIT-R1
// RUN
/*
```

In this example, ASM is the procedure name and F1 refers to the fixed disk on drive 1. SUBRA is the name of the source program. The user must substitute his own source program name. R1 is the disk pack upon which the source library resides.

Sample Assembler Procedure Stored in Procedure Library

A sample assembler procedure is shown in Figure 22. The format is as it would appear in the procedure library. The // LOAD statement and // FILE statements are as described in preceding examples.

OBJECT PROGRAM DESCRIPTION

The assembler converts the source program into a set of control information, machine language instructions, and data, all of which collectively are called an object program. There is one object program produced per assembly. Each object record is originally produced as a 64-byte field. If the object program is punched on the MFCU, it is translated into a 96-byte punch record (bytes 2 to 64 are translated 4 for 3 for punching; for every three 8-bit bytes, four card code characters are created). See *Object Program After Punch Conversion* in this section. Each object program generated by the assembler contains four types of records:

- HEADER record
- ESL (external symbol list) record
- TEXT-RLD (text-relocation directory) records
- END record

Record Formats

The following paragraphs describe the format of each record type.

HEADER Record

A HEADER record with record type H is added by the overlay linkage editor when it processes the assembler object program. The HEADER record format is:

H	Object program information field
1	2 … 64

- Byte 1 — Record type identifier H.
- Bytes 2-64 — Object program information field.

ESL Record

The object program name, that is the module name and all EXTRN and ENTRY symbols are placed in the ESL record. The ESL record format is:

S	Length -1	ESL Entries	X'00'
1	2	3 … 62	63 64

- Byte 1 — Record type identifier S.
- Byte 2 — Length -1 of the ESL entries.
- Bytes 3-62 — ESL entries. Up to five MODULE, ENTRY, and/or EXTRN fields.
- Bytes 63-64 — Filled with hexadecimal zeros.

IBM System/3 Basic Assembler Coding Form

```
// LOAD $ASSEM,F1
// FILE NAME-$SOURCE,PACK-VOL001,UNIT-R1,RETAIN-S,TRACKS-10
// FILE NAME-$WORK,PACK-VOL002,UNIT-F2,RETAIN-S,TRACKS-10
// FILE NAME-$WORK2,PACK-VOL003,UNIT-R2,RETAIN-S,TRACKS-10 (1)
// RUN
```

(1) Optional on Model 10 Disk System

Figure 22. Sample Assembler Procedure in Source Library

TEXT-RLD Records

Text records and RLD pointers are combined in this type of input record. The text portion of each record contains the object code for the program, while the RLD pointers indicate where the address constants and relocatable operands of the text are located. If the NOREL option has been selected on the OPTIONS control card, there will be no relocation indicators in the record. The format for the TEXT-RLD record is:

T	Length-1	Assembled Address		Text→ X'00' ←RLD	
1	2	3	4	5	64

- Byte 1 — Record type identifier T.
- Byte 2 — Length - 1 (of text only).
- Bytes 3-4 — Assembled address of the low order (rightmost) text byte in the record.
- Bytes 5-64 — Text starts at byte 5 and goes right, RLD starts at byte 64 and goes left. The leftmost end of the RLD section is marked by hexadecimal zeros, which fill the space between the Text and RLD sections. The end of text is always followed by at least one byte of X'00'.

END Records

The last record in each object program is an END record. It contains the entry address of the object program. If the user did not include an operand in his source program END statement, the object program END record generated by the assembler will contain the address X'FFFF'. The END record format is:

E	Entry Address	END card program
1	2-3	4

- Byte 1 — Record type identifier E.
- Bytes 2-3 — Entry address of the object program.
- Bytes 4-64 — Program to transfer control to Entry address.

Object Program After Punch Conversion

All four types of records (HEADER, ESL, TEXT-RLD, and END) assume the same format when they are punched into cards. The punched record format, using 96-column cards, is as follows:

Record ID	Data Field		Self Check Number		Identification Sequence Field	
1	2	85	86	88	89	96

Column 1	Record type identifier (H, S, T, or E).
Columns 2-85	Data field, transformed 4 for 3. (For every three 8-bit bytes, four card code characters are created for System/3 96-column cards.)
Columns 86-88	A 2-byte self check number transformed 4 for 3, to 3 bytes.
Columns 89-96	Identification/sequence field.

The punched record format, using 80-column cards, is as follows:

Record ID	Data Field		Blank		Self Check Number		Identification Sequence Field	
1	2	64	65	69	70	72	73	80

Column 1	Record type identifier (H, S, T, or E).
Columns 2-64	Data field, bytes 2 to 64 of the object record.
Columns 65-69	Blank.
Columns 70-72	A 2-byte self check number transformed 4 for 3, to 3 bytes.
Columns 73-80	Identification/sequence field.

Note: When an object module is punched, it is preceded by a // COPY OCL card and followed by a // CEND OCL card. These cards are provided for placing the object module in the R library with the Library Maintenance program ($MAINT).

ASSEMBLY TIME DATA FILE REQUIREMENTS

There are three data files necessary at assembly time:

1. Source file (NAME-$SOURCE)
2. Object file (NAME-$WORK)
3. Work file (NAME-$WORK2)

Model 10 Disk System: These files must be located on 5444 disk drives. If a // FILE statement is not provided for $WORK2, the assembler allocates its own work space.

Model 12: These files must be located on the simulation area.

Model 15: These files must be located on either 3340, 5444, or 5445 disk drives.

Source File ($SOURCE)

The source file is used by the assembler for storage of the source program. During the job initialization procedure, a disk system management program places the source program in the source file (if the macro processor has not loaded the file). The source records are obtained from either the system input device or a source library using the // COMPILE statement. (See *OCL statements for Assembly* in this section.) Each source record contains 96 bytes, so that eight records occupy three disk sectors in the source file. (One sector = 256 bytes, and is the smallest addressable unit on a disk.) Figure 23 is a source file space requirements table showing how many tracks are required for the size of the source program indicated.

If the assembler is processing a source file created by the macro processor, the // FILE statement for $SOURCE must correspond to the $SOURCE file produced in the macro processor run.

Object File ($WORK)

The object file is used by the assembler for intermediate storage of the object program. The object records are stored in four 64-byte entries per sector. (See *Object Program Before Conversion* in this section.) Because each track in the object file can contain 96 records on the 5444, 80 records on the 5445, or 192 records on the 3340, two tracks usually are sufficient for most assemblies.

Work File ($WORK2)

The work file is a scratch file used by the assembler throughout the assembly process for intermediate data storage. The file contains four types of data:

1. Intermediate text
2. Symbol table entries
3. Cross-reference data
4. Error information

Intermediate Text

Intermediate text is made up of fixed length (10-byte) records. The number of fixed length records is variable for each source statement, and is dependent on the statement type and the contents of the operand field.

The following rules can be used to determine intermediate text file requirements. (The rules apply only to error-free source statements. A statement that contains errors generally requires less storage space.)

All Instructions:

- One record for each machine or assembler instruction, or comment statement.
- One record if there is a name field entry.

Machine Instructions: One additional record for each term in the operand field.

Source Program Size (Statements)	Number of Tracks Required		
	5444 *	5445	3340
100	2	2	1
200	4	4	2
300	5	6	3
400	7	8	4
500	8	10	4
600	10	12	5
700	11	14	6
800	13	15	7
900	15	17	8
1000	16	19	8

*Or simulation area

Figure 23. Source File Space Requirements Chart

Assembler Instructions:

- END, ENTRY, EQU, EXTRN, ORG, USING – One additional record for each term in the operand field.

- ISEQ, PRINT, SPACE, START – One additional record for each instruction.

- TITLE – Additional records = N/8 (plus one for any non-zero remainder); where N is the number of characters in the TITLE operand field.

- DS/DC

  – One additional record for duplication factor (default or specified value).

  – One additional record for each term in the length specification.

- DC

  – Address constant–One record for each term in the address constant expression.

  – All other constants–Additional records - N/8 (plus one for any nonzero remainder); where N is the number of bytes required to contain the converted constant plus one.

Figure 24 is a sample list of instructions together with the intermediate text space requirements for each.

		Text Space
DECK	START 0	3
ENTRY	SLC A(2),A	5
	MVC A(2),CON1	4
	ALC A(2),CON2	4
	HPL X'FF',X'FF'	3
A	DS CL2	4
CON1	DC IL2'500'	5
CON2	DC IL2'-320'	5
	END ENTRY	2

Figure 24. Intermediate Text Space Requirements

Symbol Table Entries

Whenever a symbol is used in the name field of an instruction (except a TITLE statement) it becomes a symbol table entry. When the assembler user requests a cross reference, all symbol table entries are added to the work file immediately after the intermediate text. The symbol table entries are also 10-byte, fixed-length records. Assuming an average of one name entry for every four source statements, one sector per 100 source statements is required.

Cross-Reference Data

Cross-reference data is written in the same area as the intermediate text and symbol table entries and does not impose any additional space requirements.

Error Information

Each statement in error requires a 10-byte error record; therefore, a track will contain at least 600 error records.

Work File Space Requirements

Figure 25 is a work file space requirements table showing the number of tracks required for the number of source statements indicated. The requirements for intermediate text and symbol table entries are summed to get the table values. Approximately 40 sectors per 100 source statements are needed to cover most varieties of source statements. If a $WORK2 // FILE statement is not provided on the Model 10 disk system assembler, the source file ($SOURCE) size is used for the work file size.

Source Program Size (Statements)	Number of Tracks Required		
	5444*	5445	3340
100	2	2	1
200	4	4	2
300	6	6	3
400	7	8	4
500	9	10	5
600	11	12	6
700	12	14	6
800	14	16	7
900	16	18	8
1000	18	20	9

*Or simulation area

Figure 25. Work File Space Requirements Chart

OPERATING PROCEDURES

Placing Assembler Subroutines in R (Routine) Library

Assembler subroutines can be placed on disk in the R library by two methods.

1. Punching an object deck and using the Library Maintenance program ($MAINT) to place it in the R library.

2. Specifying OBJ in the OPTIONS statement to place the object program directly into the R library. The retain entry can be either temporary or permanent.

For more information on the OCL and utility control statements needed to use $MAINT, see *IBM System/3 Model 10 Disk System Control Programming Reference Manual,* GC21-7512, *IBM System/3 Model 12 System Control Programming Reference Manual,* GC21-5130, or *IBM System/3 Model 15 System Control Programming Reference Manual,* GC21-5077.

Placing a Punched Object Program in the R Library

In the sample procedure shown below, the subroutine SUBRA is being placed in the R library from a punched object deck.

// LOAD Statement: In this sample procedure, $MAINT is the routine which interrogates the // COPY statement and calls the proper routine to accomplish the desired results.

F1 is the disk pack upon which the utility program resides.

// COPY Statement: The FROM parameter names the device holding the subroutine to be entered. The READER option must be used to copy the assembler punched object program.

The LIBRARY parameter, R, specifies a relocatable library. The NAME parameter gives the name of the subroutine to be entered. This name must be the same as the program name (that is the name on the START instruction). The following names are restricted and cannot be used in this parameter:

- ALL
- DIR
- SYSTEM

The TO parameter specifies the physical destination of the object program (in this case, R1).

The RETAIN parameter specifies the ultimate disposition of the object program.

// CEND (Copy End) Statement: The // CEND statement must follow the object deck.

// END: The // END statement must be the end of all library maintenance decks.

Placing an Object Program Directly in the R Library

When the object program is placed directly in the R library, it has the following characteristics in the library.

- *Name* of the object program is the module name specified in the START instruction or the default module name. See the MODULE NAME MISSING diagnostic in *Appendix C. System/3 Assembler – Source Language Error Codes and Diagnostics.*

- *Retain* entry in the library is temporary if OBJ or OBJ(T) is specified and permanent if OBJ(P) is specified.

IBM System/3 Basic Assembler Coding Form

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC	PAGE
PROGRAMMER	DATE		PUNCH	CARD ELECTRO

```
/*
// LOAD $MAINT,F1
// RUN
// COPY FROM-READER,LIBRARY-R,NAME-SUBRA,TO-R1,RETAIN-P
       }
       }
   Object Deck
       }
       }
// CEND
// END
/*
```

- *Library* to receive the object program is the disk specified in the OBJECT operand of the // COMPILE statement. The default disk is the program disk.

Using Assembler Object Program with the Program Loader

The user may have the need to load a user-written assembler object program as a stand-alone program. To use an assembler object program in this manner it is necessary to have the program punched into an object deck on the system punch device. The assembler language user obtains an absolute loader by specifying DECK and NOREL on the OPTIONS card (see NOREL option under *OPTIONS Statement*). The 96-column loader contains six cards and the 80-column loader contains one card.

It is the user's responsibility to ensure:

1. That he has not referenced any address greater than the storage capacity of the System/3 on which the program is to be executed.

2. That the address specified on the START instruction statement is greater than X'FF'. (The START assembler statement must specify the address at which the program is to be loaded.)

3. That the END statement indicates the start-of-control address.

Note: If absolute object decks for more than one assembly are to be loaded together, then the loader must be removed from the front of the second and all subsequent decks, and the END card must be removed from the back of all decks except the last.

IBM 5424 MFCU

The procedure for loading and executing an assembler object program on the IBM 5424 MFCU is as follows:

1. Clear MFCU.

2. Place assembler object deck, including the loader, in primary hopper.

3. Press MFCU START.

4. Ready the printer.

5. Set IPL SELECTOR to MFCU for Model 10 Disk System or ALT for Models 12 and 15.

6. Press console PROGRAM LOAD to load and execute the assembler object program. (L1 or L2 halt is issued for error or not ready conditions on the MFCU.)

IBM 2560 MFCM (Model 15 only)

The procedure for loading and executing an assembler object program on the IBM 2560 MFCM is as follows:

1. Clear MFCM.

2. Place assembler object deck, including the loader, in primary hopper.

3. Press MFCM START.

4. Ready the printer.

5. Set IPL SELECTOR to ALT.

6. Press console PROGRAM LOAD to load and execute the assembler object program. (L1 halt is issued for error or not ready conditions on the MFCM.)

IBM 1442 Card Read Punch (Models 12 and 15)

The procedure for loading and executing an assembler object program on the IBM 1442 Card Read Punch is as follows:

1. Clear 1442.

2. Place assembler object deck, including the loader, in hopper.

3. Press 1442 START.

4. Ready the printer.

5. Set IPL SELECTOR to ALT.

6. Press console PROGRAM LOAD to load and execute the assembler object program. (L1 halt is issued for error or not ready conditions on the 1442.)

ASSEMBLER LISTING

An important part of the assembler's output is the assembler listing. The assembler's printed output is on the system printer (under control of the // PRINTER OCL statement for Models 12 and 15).

The listing is a printed reproduction of the source program and the corresponding object code generated for it together with other important information. Figure 26 at the back of this section is a sample listing. Specifically, the listing consists of the following:

Control Statements

Any OPTIONS or HEADERS statements specified by the user are printed and specification errors are noted. A list of OPTIONS in effect during the assembly is then printed. The page is ejected before the control statement information is listed.

External Symbol List (ESL)

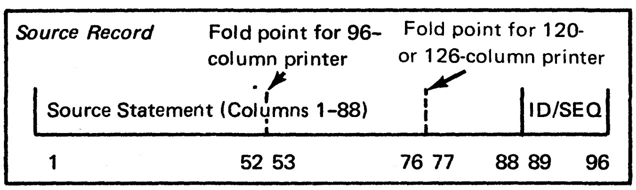
The object program name, EXTRNs, and ENTRYs will appear in the following format:

Symbol	*Type*
Program name	MODULE
ENTRY symbol	ENTRY
EXTRN symbol	EXTRN

Source and Object Listing

The source and object listing consists of the following:

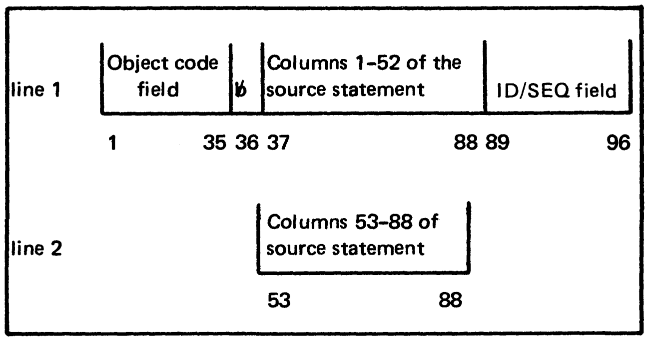
- Error code for improperly coded statements (see *Diagnostics* in this section).
- Location counter value, in hexadecimal, of the high order address of the object code generated by the corresponding source statement.
- The object code, in hexadecimal, generated by the corresponding statement.
- The value, in hexadecimal, of the expression in the operand field of the EQU, USING, DROP, and END statements, the storage address, in hexadecimal, of the low order address of the DC constants, and DS storage areas.
- Statement number, in decimal, for each statement, including comment statements. These numbers are assigned by the assembler. The statement number is a four-digit field which limits the assembly to 9,999 statements.
- The source image, which is formatted according to the size of the printer used:



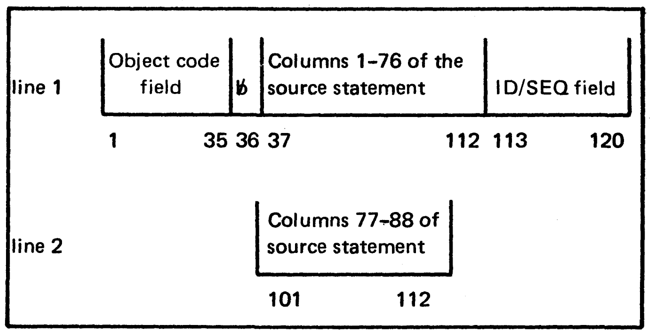
The following examples assume the ID/SEQ field is in columns 89-96 of the source record:

Note: The ID/SEQ field may be from one to eight adjacent characters long and may reside anywhere between columns 73-96.

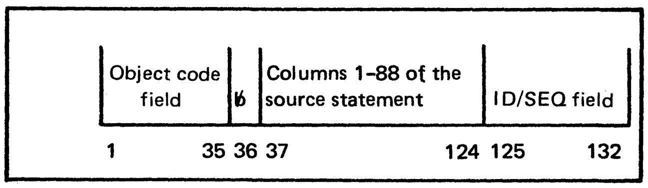
1. On a 96-column printer, the ID/SEQ field is left-justified in columns 89-96 of the print line. If columns 53-88 of the source statement are blank, line 2 will not be printed.



2. On a 120-column or 126-column printer, the ID/SEQ field is left-justified in columns 113-120 of the print line. If columns 77-88 of the source statement are blank, or if the start of the ID/SEQ field on the source record is less than column 77, line 2 will not be printed.



3. With the 132-column printer, the complete source image is printed on one line.



Note: Statements generated by the macro processor contain a plus symbol (+) in column 36.

Diagnostics

The source and object program listing includes error codes for improperly coded statements. These errors are listed again, with a message, at the end of the source and object program listing under the heading DIAGNOSTICS. This list provides the following information:

- Statement—The statement number, in decimal, (assigned by the assembler) of the statement which is in error.
- Error code—a 3-digit alphameric code. See *Appendix C: System/3 Assembler–Source Language Error Codes and Diagnostics* for a list of error codes and translations.
- Message—A translation of the error code indicating the type of error made.

Also included under DIAGNOSTICS are the following error summary statements:

- A count of the total statements in error in the assembly.
- A count of total sequence errors in the assembly if sequence check is requested.

Cross-Reference List

If XREF is specified on the OPTIONS statement this list includes all symbol names referred to in the source program. The following columns are included:

- Symbol—The symbol name.
- Length—The decimal length attribute of the symbol in bytes.
- Values—Value, in hexadecimal, of the symbol.
- Defined—Statement number, in decimal, where the symbol is defined.
- References—Statement numbers, in decimal, where the symbol is referenced. Symbolic references to data areas and machine registers whose contents may be altered by execution of a machine instruction are flagged with an asterisk.

At the end of the cross-reference list, the error summary statements are printed again.

```
SUBRC                                   EXTERNAL SYMBOL LIST

SYMBOL    TYPE                                                     VER 00, MOD 00  01/30/76  PAGE 1

SUBRC     MODULE
```

```
SUBRC  SAMPLE EXIT SUBROUTINE--FIELD AND INDICATOR

ERR LOC  OBJECT CODE       ADDR STMT SOURCE STATEMENT                VER 00, MOD 00  01/30/76  PAGE 2

                                   2 ***********************************************************************
                                   3 *                                                                     *
                                   4 * NAME ............ SUBRC.                                            *
                                   5 *                                                                     *
                                   6 * FUNCTION ........ EXIT SUBROUTINE WITH FIELD AND INDICATOR          *
                                   7 *                     PARAMETERS.                                     *
                                   8 *                                                                     *
                                   9 *                   THE CODE GENERATED BY THE COMPILER IS AS FOLLOWS: *
                                  10 *                                                                     *
                                  11 *                         B       SUBRC                               *
                                  12 *                         DC      IL1'FIELD LENGTH-1'                 *
                                  13 *                         DC      AL2'ADDRESS OF RIGHT OF FIELD'      *
                                  14 *                         DC      XL1'00'                             *
                                  15 *                         DC      XL1'INDICATOR MASK'                 *
                                  16 *                         DC      XL1'REGISTER 1 DISPLACEMENT'        *
                                  17 *                                                                     *
                                  18 ***********************************************************************
    0000                          19 SUBRC   START 0
    0000 34 08 0C13               20         ST    GET+3,ARR                 SAVE PARM ADDR
    0004 36 08 0C31               21         A     CON6,ARR                  INCREMENT TO RETURN
    0008 34 C8 0C2F               22         ST    RET+3,ARR                 SAVE RETURN
    000C 34 C2 0C2B               23         ST    SAVE+3,2                  SAVE XR2
    0010 C2 02 0CCC               24 GET     LA    *-*,2                     GET PARMETER ADDRESS
    0014 2C 01 0C1B 05            25         MVC   TEST+2(2),5(,2)           MOVE IN MASK AND DISPLACEMENT
    0019 78 00 0C                 26 TEST    TBN   *-*(,1),*-*               TEST INDICATOR
    001C F2 90 09                 27         JF    SAVE                      INDICATOR OFF
    001F B5 02 02                 28         L     2(,2),2                   GET CONTROL FIELD ADDRESS
    0022 B5 02 05                 29         L     5(,2),2                   GET LOOK UP ADDRESS
    0025 BC C3 00                 30         MVI   0(,2),C'C'                MOVE IN C'C'
    0028 C2 02 0CCC               31 SAVE    LA    *-*,2                     RESTORE
    002C C0 87 0CCC               32 RET     B     *-*                       RETURN
    0030 0006               0031  33 CON6    DC    IL2'6'
                            0008  34 ARR     EQU   8
                            FFFF  35         END

TOTAL STATEMENTS IN ERROR IN THIS ASSEMBLY =      0
```

```
SUBRC                                   CROSS REFERENCE

SYMBOL   LEN  VALUE DEFN   REFERENCES                          VER 00, MOD 00  01/30/76  PAGE 3

ARR      001  0008  0034   002C  0021* 0022
CON6     002  0031  0033   0021
GET      004  001C  0024   0020*
RET      004  002C  0032   0022*
SAVE     004  0028  0031   0023* 0027
SUBRC    001  000C  0019
TEST     003  0019  0026   0025*

TOTAL STATEMENTS IN ERROR IN THIS ASSEMBLY =      0
```

Figure 26. Sample Assembler Listing

External Symbol List (ESL) Table Size

The ESL table is an execution time main storage table containing the module name (START statement name or ASMOBJ) and each EXTRN and ENTRY symbol defined in an assembly. The total of EXTRNs and ENTRYs allowed in a single assembly is limited by the ESL table size.

Using the Model 10 disk system assembler, the limit is 74 EXTRNs and ENTRYs.

Using the Model 12 and Model 15 assembler, the limit varies with the amount of storage available in the execution partition. The limiting sizes and associated storage ranges are:

Storage Available	*Limit of EXTRNs and ENTRYs*
10K	84
12K	124
14K	169
16K	209
18K - 48K	254

MACHINE LANGUAGE INSTRUCTION FORMATS

Operation Code

The first byte of each instruction, the operation code, specifies the addressing modes to be employed by the instruction in bits 0 through 3, and the operation to be performed in bits 4 through 7.

Q Code

The second byte of each instruction is the Q code. In 2-address formats, the Q code is always a length count. In other formats, depending upon the operation specified, the Q code can be:

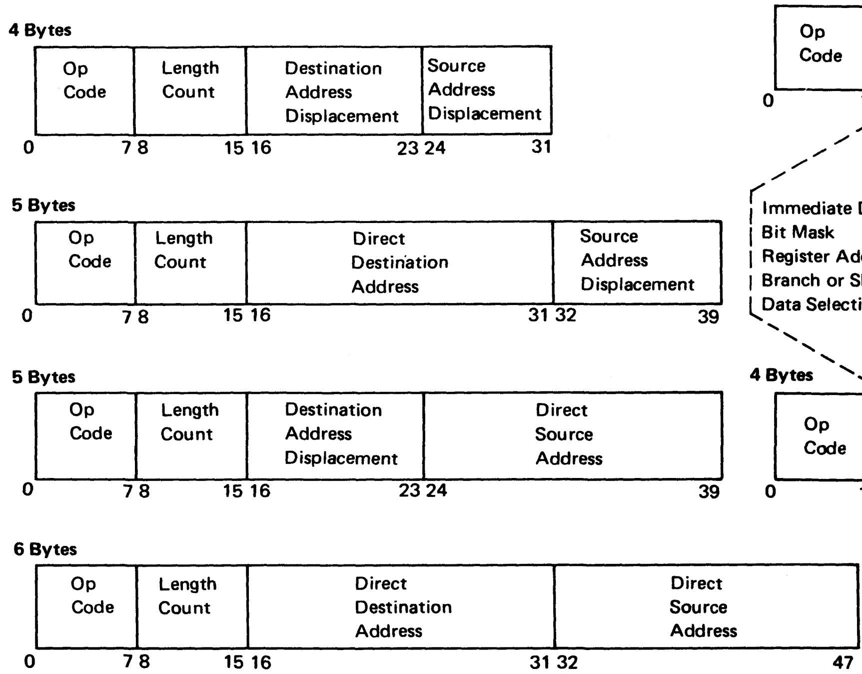
- Length count
- Immediate data
- Bit mask
- Register address
- Data selection
- Branch or skip condition
- Device address and functional specifications

Control Code

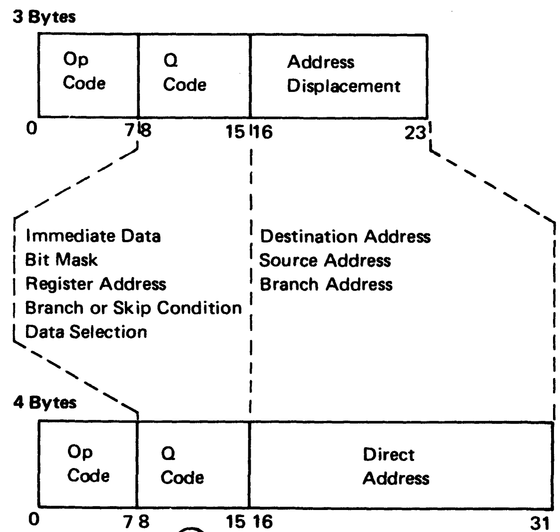
The third byte of an instruction in the Command Format contains additional data pertaining to the command to be executed.

Storage Addresses

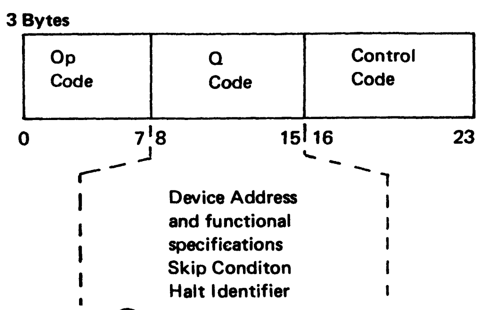
For instructions in the 1-operand and 2-operand formats, the third byte of the instruction and all bytes following are storage address information.



Ⓐ Two-Address Formats



Ⓑ One-Address Formats



Ⓒ Command Format

Op	Mnemonic	Type
04	ZAZ	
06	AZ	←2 ADDRESS→
07	SZ	
08	MVX	Direct
0A	ED	[Op] [Q] [Operand One] [Operand Two]
0B	ITC	
0C	MVC	←6 bytes→
0D	CLC	
0E	ALC	
0F	SLC	
14	ZAZ	
16	AZ	←2 ADDRESS→
17	SZ	
18	MVX	Direct Indexed
1A	ED	[Op] [Q] [Operand One] [D2]
1B	ITC	
1C	MVC	←5 bytes→
1D	CLC	
1E	ALC	R1
1F	SLC	
24	ZAZ	
26	AZ	←2 ADDRESS→
27	SZ	
28	MVX	Direct Indexed
2A	ED	[Op] [Q] [Operand One] [D2]
2B	ITC	
2C	MVC	←5 bytes→
2D	CLC	
2E	ALC	R2
2F	SLC	
30	SNS	
31	LIO	1 ADDRESS ←→
34	ST	
35	L	Direct
36	A	[Op] [Q] [Operand One]
38	TBN	
39	TBF	←4 bytes→
3A	SBN	
3B	SBF	
3C	MVI	
3D	CLI	
3E	SCP*	
3F	LCP*	
44	ZAZ	
46	AZ	←2 ADDRESS→
47	SZ	
48	MVX	
4A	ED	[Op] [Q] [D1] [Operand Two]
4B	ITC	
4C	MVC	←5 bytes→
4D	CLC	
4E	ALC	R1
4F	SLC	
54	ZAZ	
56	AZ	2 ADDRESS ←→
57	SZ	
58	MVX	Indexed
5A	ED	[Op] [Q] [D1] [D2]
5B	ITC	
5C	MVC	←4 bytes→
5D	CLC	
5E	ALC	R1 R1
5F	SLC	
64	ZAZ	
66	AZ	←2 ADDRESS→
67	SZ	
68	MVX	
6A	ED	[Op] [Q] [D1] [D2]
6B	ITC	
6C	MVC	←4 bytes→
6D	CLC	
6E	ALC	R1 R2
6F	SLC	
70	SNS	
71	LIO	1 ADDRESS
74	ST	←→
75	L	
76	A	[Op] [Q] [D1]
78	TBN	
79	TBF	←3 bytes→
7A	SBN	
7B	SBF	
7C	MVI	R1
7D	CLI	
7E	SCP*	
7F	LCP*	
84	ZAZ	
86	AZ	←2 ADDRESS→
87	SZ	
88	MVX	Indexed Direct
8A	ED	[Op] [Q] [D1] [Operand Two]
8B	ITC	
8C	MVC	←5 bytes→
8D	CLC	
8E	ALC	R2
8F	SLC	
94	ZAZ	
96	AZ	←2 ADDRESS→
97	SZ	
98	MVX	Indexed
9A	ED	[Op] [Q] [D1] [D2]
9B	ITC	
9C	MVC	←4 bytes→
9D	CLC	
9E	ALC	R2 R1
9F	SLC	
A4	ZAZ	
A6	AZ	←2 ADDRESS→
A7	SZ	
A8	MVX	Indexed
AA	ED	[Op] [Q] [D1] [D2]
AB	ITC	
AC	MVC	←4 bytes→
AD	CLC	
AE	ALC	R2 R2
AF	SLC	

* Model 15 only.

Legend:

D1 – Displacement, operand 1
D2 – Displacement, operand 2
R1 – Register 1
R2 – Register 2

Op	Mnemonic	Type
B0	SNS	
B1	LIO	1 ADDRESS
B4	ST	
B5	L	Indexed
B6	A	Op | Q | D1
B8	TBN	
B9	TDF	← 3 bytes →
BA	SBN	
BB	SBF	
BC	MVI	XR2
BD	CLI	
BE	SCP*	
BF	LCP*	
C0	BC	Direct
C1	TIO	Op | Q | Address
C2	LA	← 4 bytes →
D0	BC	
D1	TIO	Op | Q | D2 +XR1
D2	LA	← 3 bytes →
E0	BC	
E1	TIO	Op | Q | D2 +XR2
E2	LA	← 3 bytes →
F0	HPL	
F1	APL	
F2	JC	Op | Q | R
F3	SIO	← 3 bytes →
F4	CCP*	

*Model 15 only.

Bits 0-3	Op Code (one byte) Bits 4-7: 0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	Q Code One Byte	Operands: First	Operands: Second	Total Instr Length	Type	Summary: Op	Q	Operand		
0					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC		2 Bytes Direct	2 Bytes Direct	6	X					
1					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC			1 Byte Disp Index-By R1	5	X					D1
2					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC			1 Byte Disp Index-By R2	5	X					D2
3	SNS	LIO			ST	L	A		TBN	TBF	SBN	SBF	MVI	CLI	SCP*	LCP*				4	Y					
4					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC		1 Byte Displacement Indexed By R1	2 Bytes Direct	5	X			D1		
5					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC			1 Byte Disp Index-By R1	4	X			D1	D1	
6					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC			1 Byte Disp Index-By R2	4	X			D1	D2	
7	SNS	LIO			ST	L	A		TBN	TBF	SBN	SBF	MVI	CLI	SCP*	LCP*				3	Y			D1		
8					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC		1 Byte Displacement Indexed By R2	2 Bytes Direct	5	X			D2		
9					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC			1 Byte Disp Index-By R1	4	X			D2	D1	
A					ZAZ		AZ	SZ	MVX		ED	ITC	MVC	CLC	ALC	SLC			1 Byte Disp Index-By R2	4	X			D2	D2	
B	SNS	LIO			ST	L	A		TBN	TBF	SBN	SBF	MVI	CLI	SCP*	LCP*				3	Y			D2		
C	BC	TIO	LA																2 Bytes Direct	4	Z					
D	BC	TIO	LA																1 Byte Disp Index-By R1	3	Z			D1		
E	BC	TIO	LA																1 Byte Disp Index-By R2	3	Z			D2		
F	HPL	APL	JC	SIO	CCP*															3	F					

*Model 15 only.

MNEMONIC OPERATION CODES (MACHINE)

*Instruction**	*Mnemonic Operation Code*	
Zero and Add Zoned Decimal	ZAZ	Two-address Format**
Add Zoned Decimal	AZ	
Subtract Zoned Decimal	SZ	
Move Hex Character	MVX	
Move Characters	MVC	
Compare Logical Characters	CLC	
Add Logical Characters	ALC	
Subtract Logical Characters	SLC	
Insert and Test Characters	ITC	
Edit	ED	
Move Logical Immediate	MVI	One-address Format**
Compare Logical Immediate	CLI	
Set Bits On Masked	SBN	
Set Bits Off Masked	SBF	
Test Bits On Masked	TBN	
Test Bits Off Masked	TBF	
Store Register	ST	
Load Register	L	
Add to Register	A	
Branch On Condition	BC	
Test I/O and Branch	TIO	
Sense I/O	SNS	
Load I/O	LIO	
Load Address	LA	
Load CPU***	LCP	
Store CPU***	SCP	
Advance Program Level	APL	Command Format**
Halt Program Level	HPL	
Start I/O	SIO	
Command CPU***	CCP	
Jump On Condition	JC	

* For information concerning specifications for the use of these instructions with the Model 10, see the *IBM System/3 Model 10 Components Reference Manual,* GA21-9103, or with the Model 15, see the *IBM System/3 Model 15 Components Reference Manual,* GA21-9193.

** See *Machine Language Instruction Formats* in this appendix.

*** These instructions are for the Model 15 but they can also be generated on the Model 12 through the macros $LCP, $SCP, and $CCP. For more information concerning the use of the Model 12 macros, see *IBM System/3 Models 10 and 12 System Control Programming Macros Reference Manual*, GC21-7562.

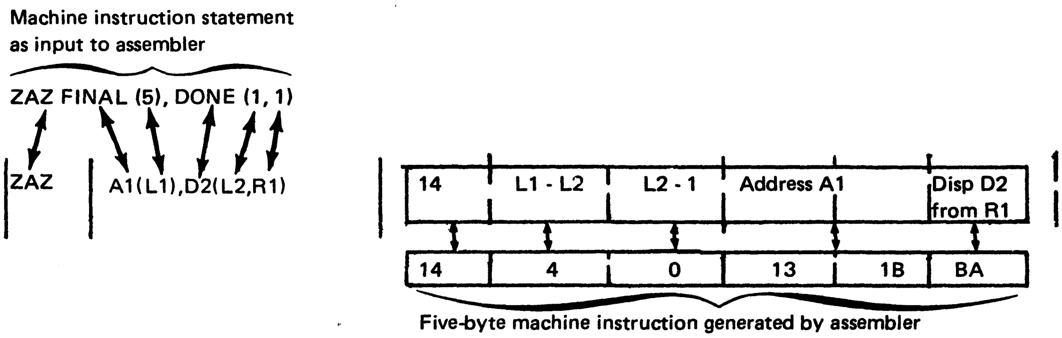
EXTENDED MNEMONIC CODES

Instruction	*Mnemonic Operation Code*	*Q Code*
Move Hex Character (MVX)		
Move to Zone from Zone	MZZ	X'00'
Move to Numeric from Zone	MNZ	X'02'
Move to Zone from Numeric	MZN	X'01'
Move to Numeric from Numeric	MNN	X'03'
Branch On Condition (BC)		
Branch	B	X'87'
Branch High	BH	X'84'
Branch Low	BL	X'82'
Branch Equal	BE	X'81'
Branch Not High	BNH	X'04'
Branch Not Low	BNL	X'02'
Branch Not Equal	BNE	X'01'
Branch Overflow Zoned	BOZ	X'88'
Branch Overflow Logical	BOL	X'A0'
Branch No Overflow Zoned	BNOZ	X'08'
Branch No Overflow Logical	BNOL	X'20'
Branch True	BT	X'10'
Branch False	BF	X'90'
Branch Plus	BP	X'84'
Branch Minus	BM	X'82'
Branch Zero	BZ	X'81'
Branch Not Plus	BNP	X'04'
Branch Not Minus	BNM	X'02'
Branch Not Zero	BNZ	X'01'
Jump On Condition (JC)		
Jump	J	X'87'
Jump High	JH	X'84'
Jump Low	JL	X'82'
Jump Equal	JE	X'81'
Jump Not High	JNH	X'04'
Jump Not Low	JNL	X'02'
Jump Not Equal	JNE	X'01'
Jump Overflow Zoned	JOZ	X'88'
Jump Overflow Logical	JOL	X'A0'
Jump No Overflow Zoned	JNOZ	X'08'
Jump No Overflow Logical	JNOL	X'20'
Jump True	JT	X'10'
Jump False	JF	X'90'
Jump Plus	JP	X'84'
Jump Minus	JM	X'82'
Jump Zero	JZ	X'81'
Jump Not Plus	JNP	X'04'
Jump Not Minus	JNM	X'02'
Jump Not Zero	JNZ	X'01'
Command CPU (CCP–Model 15 only)		
Supervisor Call	SVC	X'10'

Assembler Language to Machine Language Relationships

The following charts show the relationship between a machine instruction statement as coded by the System/3 Basic Assembler Language programmer and the machine language as generated by the assembler.

For example, the instruction coded by the programmer is ZAZ FINAL(5),DONE(1,1). From the second line of the first of the charts we can develop the relationship between the instruction and the machine code as follows (assume FINAL is a relocatable symbol with value X'131B' and DONE is an absolute symbol with value X'BA'):



Used in this manner, the following charts show what machine code results from a particular assembler language statement, and vice versa, what assembler language format obtains a particular machine code format.

The abbreviations used on the following pages mean:

A1	Direct address, operand 1
A2	Direct address, operand 2
D1	Displacement, operand 1
D2	Displacement, operand 2
L1	Length of operand 1
L2	Length of operand 2
R1	Register 1
R2	Register 2
RX	Local storage register
I	Immediate data

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
ZAZ	A1(L1),A2(L2)	04	L1-L2 L2-1	Address A1		Address A2	
ZAZ	A1(L1),D2(L2,R1)	14	L1-L2 L2-1	Address A1		Disp D2 from R1	
ZAZ	A1(L1),D2(L2,R2)	24	L1-L2 L2-1	Address A1		Disp D2 from R2	
ZAZ	D1(L1,R1),A2(L2)	44	L1-L2 L2-1	Disp D1 from R1	Address A2		
ZAZ	D1(L1,R1),D2(L2,R1)	54	L1-L2 L2-1	Disp D1 from R1	Disp D2 from R1		
ZAZ	D1(L1,R1),D2(L2,R2)	64	L1-L2 L2-1	Disp D1 from R1	Disp D2 from R2		
ZAZ	D1(L1,R2),A2(L2)	84	L1-L2 L2-1	Disp D1 from R2	Address A2		
ZAZ	D1(L1,R2),D2(L2,R1)	94	L1-L2 L2-1	Disp D1 from R2	Disp D2 from·R1		
ZAZ	D1(L1,R2),D2(L2,R2)	A4	L1-L2 L2-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

If L1 or L2 is not specified, the implied length is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
AZ	A1(L1),A2(L2)	06	L1-L2 | L2-1	Address A1		Address A2	
AZ	A1(L1),D2(L2,R1)	16	L1-L2 | L2-1	Address A1		Disp D2 from R1	
AZ	A1(L1),D2(L2,R2)	26	L1-L2 | L2-1	Address A1		Disp D2 from R2	
AZ	D1(L1,R1),A2(L2)	46	L1-L2 | L2-1	Disp D1 from R1	Address A2		
AZ	D1(L1,R1),D2(L2,R1)	56	L1-L2 | L2-1	Disp D1 from R1	Disp D2 from R1		
AZ	D1(L1,R1),D2(L2,R2)	66	L1-L2 | L2-1	Disp D1 from R1	Disp D2 from R2		
AZ	D1(L1,R2),A2(L2)	86	L1-L2 | L2-1	Disp D1 from R2	Address A2		
AZ	D1(L1, R2), D2(L2, R1)	96	L1-L2 | L2-1	Disp D1 from R2	Disp D2 from R1		
AZ	D1(L1,R2),D2(L2,R2)	A6	L1-L2 | L2-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

If L1 or L2 is not specified, the implied length is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	**Operands**	**Op-Code**	**Q-Code**	**Operands**			
		Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**
SZ	A1(L1),A2(L2)	07	L1-L2 | L2-1	Address A1		Address A2	
SZ	A1(L1),D2(L2,R1)	17	L1-L2 | L2-1	Address A1		Disp D2 from R1	
SZ	A1(L1), D2(L2,R2)	27	L1-L2 | L2-1	Address A1		Disp D2 from R2	
SZ	D1(L1,R1),A2(L2)	47	L1-L2 | L2-1	Disp D1 from R1	Address A2		
SZ	D1(L1,R1),D2(L2,R1)	57	L1-L2 | L2-1	Disp D1 from R1	Disp D2 from R1		
SZ	D1(L1,R1),D2(L2,R2)	67	L1-L2 | L2-1	Disp D1 from R1	Disp D2 from R2		
SZ	D1(L1,R2),A2(L2)	87	L1-L2 | L2-1	Disp D1 from R2	Address A2		
SZ	D1(L1,R2),D2(L2,R1)	97	L1-L2 | L2-1	Disp D1 from R2	Disp D2 from R1		
SZ	D1(L1,R2),D2(L2,R2)	A7	L1-L2 | L2-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

If L1 or L2 is not specified, the implied length is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
MVX	A1(I),A2	08	I	Address A1		Address A2	
MVX	A1(I),D2(,R1)	18	I	Address A1		Disp D2 from R1	
MVX	A1(I),D2(,R2)	28	I	Address A1		Disp D2 from R2	
MVX	D1(I,R1),A2	48	I	Disp D1 from R1	Address A2		
MVX	D1(I,R1),D2(,R1)	58	I	Disp D1 from R1	Disp D2 from R1		
MVX	D1(I,R1),D2(,R2)	68	I	Disp D1 from R1	Disp D2 from R2		
MVX	D1(I,R2),A2	88	I	Disp D1 from R2	Address A2		
MVX	D1(I,R2),D2(,R1)	98	I	Disp D1 from R2	Disp D2 from R1		
MVX	D1(I,R2),D2(,R2)	A8	I	Disp D1 from R2	Disp D2 from R2		

NOTES:

I may be specified on either operand, and must have the value X'00',X'01',X'02', or X'03'.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

For the extended mnemonics of the MVX instruction, I-field information is inherent in the mnemonic and the I-field is omitted from the operand field. See *Extended Mnemonic Codes* for the extended MVX and the associated Q-codes.

Assembler Instruction Format		Machine Instruction Format					
Operation	**Operands**	**Op-Code**	**Q-Code**	**Operands**			
		Byte 1	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**
MVC	A1(L1),A2	0C	L1-1	Address A1		Address A2	
MVC	A1(L1),D2(,R1)	1C	L1-1	Address A1		Disp D2 from R1	
MVC	A1(L1),D2(,R2)	2C	L1-1	Address A1		Disp D2 from R2	
MVC	D1(L1,R1),A2	4C	L1-1	Disp D1 from R1	Address A2		
MVC	D1(L1,R1),D2(,R1)	5C	L1-1	Disp D1 from R1	Disp D2 from R1		
MVC	D1(L1,R1),D2(,R2)	6C	L1-1	Disp D1 from R1	Disp D2 from R2		
MVC	D1(L1,R2),A2	8C	L1-1	Disp D1 from R2	Address A2		
MVC	D1(L1,R2),D2(,R1)	9C	L1-1	Disp D1 from R2	Disp D2 from R1		
MVC	D1(L1,R2),D2(,R2)	AC	L1-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

L1 may be specified on either operand; if L1 is not specified, the implied length of operand one is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
CLC	A1(L1),A2	0D	L1-1	Address A1		Address A2	
CLC	A1(L1),D2(,R1)	1D	L1-1	Address A1		Disp D2 from R1	
CLC	A1(L1),D2(,R2)	2D	L1-1	Address A1		Disp D2 from R2	
CLC	D1(L1,R1),A2	4D	L1-1	Disp D1 from R1	Address A2		
CLC	D1(L1,R1),D2(,R1)	5D	L1-1	Disp D1 from R1	Disp D2 from R1		
CLC	D1(L1,R1),D2(,R2)	6D	L1-1	Disp D1 from R1	Disp D2 from R2		
CLC	D1(L1,R2),A2	8D	L1-1	Disp D1 from R2	Address A2		
CLC	D1(L1,R2),D2(,R1)	9D	L1-1	Disp D1 from R2	Disp D2 from R1		
CLC	D1(L1,R2),D2(,R2)	AD	L1-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

L1 may be specified on either operand; if L1 is not specified, the implied length of operand one is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
ALC	A1(L1),A2	0E	L1-1	Address A1		Address A2	
ALC	A1(L1),D2(,R1)	1E	L1-1	Address A1		Disp D2 from R1	
ALC	A1(L1),D2(,R2)	2E	L1-1	Address A1		Disp D2 from R2	
ALC	D1(L1,R1),A2	4E	L1-1	Disp D1 from R1	Address A2		
ALC	D1(L1,R1),D2(,R1)	5E	L1-1	Disp D1 from R1	Disp D2 from R1		
ALC	D1(L1,R1),D2(,R2)	6E	L1-1	Disp D1 from R1	Disp D2 from R2		
ALC	D1(L1,R2),A2	8E	L1-1	Disp D1 from R2	Address A2		
ALC	D1(L1,R2),D2(,R1)	9E	L1-1	Disp D1 from R2	Disp D2 from R1		
ALC	D1(L1,R2),D2(,R2)	AE	L1-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

L1 may be specified on either operand; if L1 is not specified, the implied length of operand one is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SLC	A1(L1),A2	0F	L1-1	Address A1		Address A2	
SLC	A1(L1),D2(,R1)	1F	L1-1	Address A1		Disp D2 from R1	
SLC	A1(L1),D2(,R2)	2F	L1-1	Address A1		Disp D2 from R2	
SLC	D1(L1,R1),A2	4F	L1-1	Disp D1 from R1	Address A2		
SLC	D1(L1,R1),D2(,R1)	5F	L1-1	Disp D1 from R1	Disp D2 from R1		
SLC	D1(L1,R1),D2(,R2)	6F	L1-1	Disp D1 from R1	Disp D2 from R2		
SLC	D1(L1,R2),A2	8F	L1-1	Disp D1 from R2	Address A2		
SLC	D1(L1,R2),D2(,R1)	9F	L1-1	Disp D1 from R2	Disp D2 from R1		
SLC	D1(L1,R2),D2(,R2)	AF	L1-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

L1 may be specified on either operand; if L1 is not specified, the implied length of operand one is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
ITC	A1(L1),A2	0B	L1-1	Address A1		Address A2	
ITC	A1(L1),D2(,R1)	1B	L1-1	Address A1		Disp D2 from R1	
ITC	A1(L1),D2(,R2)	2B	L1-1	Address A1		Disp D2 from R2	
ITC	D1(L1,R1),A2	4B	L1-1	Disp D1 from R1	Address A2		
ITC	D1(L1,R1),D2(,R1)	5B	L1-1	Disp D1 from R1	Disp D2 from R1		
ITC	D1(L1,R1),D2(,R2)	6B	L1-1	Disp D1 from R1	Disp D2 from R2		
ITC	D1(L1,R2),A2	8B	L1-1	Disp D1 from R2	Address A2		
ITC	D1(L1,R2),D2(,R1)	9B	L1-1	Disp D1 from R2	Disp D2 from R1		
ITC	D1(L1,R2),D2(,R2)	AB	L1-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

Operand one must address the data field at the leftmost byte.

L1 may be specified on either operand; if L1 is not specified, the implied length of operand one is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
ED	A1(L1),A2	0A	L1-1	Address A1		Address A2	
ED	A1(L1),D2(,R1)	1A	L1-1	Address A1		Disp D2 from R1	
ED	A1(L1),D2(,R2)	2A	L1-1	Address A1		Disp D2 from R2	
ED	D1(L1,R1),A2	4A	L1-1	Disp D1 from R1	Address A2		
ED	D1(L1,R1),D2(,R1)	5A	L1-1	Disp D1 from R1	Disp D2 from R1		
ED	D1(L1,R1),D2(,R2)	6A	L1-1	Disp D1 from R1	Disp D2 from R2		
ED	D1(L1,R2),A2	8A	L1-1	Disp D1 from R2	Address A2		
ED	D1(L1,R2),D2(,R1)	9A	L1-1	Disp D1 from R2	Disp D2 from R1		
ED	D1(L1,R2),D2(,R2)	AA	L1-1	Disp D1 from R2	Disp D2 from R2		

NOTES:

L1 may be specified on either operand; if L1 is not specified, the implied length of operand one is used.

If D1 or D2 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
MVI	A1,I	3C	I	Address A1			
MVI	D1(,R1),I	7C	I	Disp D1 from R1			
MVI	D1(,R2),I	BC	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
CLI	A1,I	3D	I	Address A1			
CLI	D1(,R1),I	7D	I	Disp D1 from R1			
CLI	D1(,R2),I	BD	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SBN	A1,I	3A	I	Address A1			
SBN	D1(,R1),I	7A	I	Disp D1 from R1			
SBN	D1(,R2),I	BA	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SBF	A1,I	3B	I	Address A1			
SBF	D1(,R1),I	7B	I	Disp D1 from R1			
SBF	D1(,R2),I	BB	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
TBN	A1,I	38	I	Address A1			
TBN	D1(,R1),I	78	I	Disp D1 from R1			
TBN	D1(,R2),I	B8	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
TBF	A1,I	39	I	Address A1			
TBF	D1(,R1),I	79	I	Disp D1 from R1			
TBF	D1(,R2),I	B9	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
ST	A1,RX	34	RX	Address A1			
ST	D1(,R1),RX	74	RX	Disp D1 from R1			
ST	D1(,R2),RX	B4	RX	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
L	A1,RX	35	RX	Address A1			
L	D1(,R1),RX	75	RX	Disp D1 from R1			
L	D1(,R2),RX	B5	RX	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
A	A1,RX	36	RX	Address A1			
A	D1(,R1),RX	76	RX	Disp D1 from R1			
A	D1(,R2),RX	B6	RX	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
BC	A1,I	C0	I	Address A1			
BC	D1(,R1),I	D0	I	Disp D1 from R1			
BC	D1(,R2),I	E0	I	Disp D1 from R2			

NOTES:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

For the extended mnemonics of the BC, the second operand (I-field) is not used since the information is inherent in the mnemonic. See *Extended Mnemonic Codes* for the extended branches and their associated Q-codes.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
TIO	A1,I	C1	I	Address A1			
TIO	D1(,R1),I	D1	I	Disp D1 from R1			
TIO	D1(,R2),I	E1	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SNS	A1,I	30	I	Address A1			
SNS	D1(,R1),I	70	I	Disp D1 from R1			
SNS	D1(,R2),I	B0	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
LIO	A1,I	31	I	Address A1			
LIO	D1(,R1),I	71	I	Disp D1 from R1			
LIO	D1(,R2),I	B1	I	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
LA	A1,RX	C2	RX	Address A1			
LA	D1(,R1),RX	D2	RX	Disp D1 from R1			
LA	D1(,R2),RX	E2	RX	Disp D1 from R2			

NOTE:

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
LCP	A1,RX	3F	RX	Address A1			
LCP	D1(,R1),RX	7F	RX	Disp D1 from R1			
LCP	D1(,R2),RX	BF	RX	Disp D1 from R2			

NOTES:

The Model 15 LCP instruction can also be generated on the Model 12 through the $LCP macro instruction; see *IBM System/3 Models 10 and 12 System Control Programming Macros Reference Manual*, GC21-7562.

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SCP	A1,RX	3E	RX	Address A1			
SCP	D1(,R1),RX	7E	RX	Disp D1 from R1			
SCP	D1(,R2),RX	BE	RX	Disp D1 from R2			

NOTES:

The Model 15 SCP instruction can also be generated on the Model 12 through the $SCP macro instruction; see *IBM System/3 Models 10 and 12 System Control Programming Macros Reference Manual*, GC21-7562.

If D1 is relocatable, the assembler computes the displacement based on the USING instruction.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
APL	I	F1	I	00			

NOTE:

The APL is a NO-OP instruction on the Model 15.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
HPL	I1,I2	F0	I2	I1			

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
SIO	I1,I2	F3	I2	I1			

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
CCP	I1,RX	F4	RX	I1			

NOTES:

The Model 15 CCP instruction can also be generated on the Model 12 through the $CCP macro instruction; see *IBM System/3 Models 10 and 12 System Control Programming Macros Reference Manual*, GC21-7562.

For the SVC form of the CCP instruction, the Q-code is inherent in the mnemonic and the RX field is omitted from the operand field. See *Extended Mnemonic Codes* for the associated Q-code.

Assembler Instruction Format		Machine Instruction Format					
Operation	Operands	Op-Code	Q-Code	Operands			
		Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
JC	A1,I	F2	I	*			

*If the first operand is absolute, this value is placed in byte 3.
If the first operand is relocatable, the displacement from the next sequential instruction to address A1 is placed in byte 3.

NOTE:

For the extended mnemonics of the JC, the second operand (I-field) is not used since the information is inherent in the mnemonic. See *Extended Mnemonic Codes* for the extended jumps and their associated Q-codes.

Operation Entry	Name Entry	Operand Entry
DC	Any Symbol or Blank	One operand entry containing: Duplication Factor, Type, Length, Constant.
DROP	Blank	Specified register (1 or 2).
DS	Any Symbol or Blank	One operand entry containing: Duplication Factor, Type, Length.
EJECT	Blank	Blank.
END	Blank	A relocatable expression or blank.
ENTRY	Blank	Any relocatable name entry found in the current program.
EQU	Any Symbol	An expression.
EXTRN	Blank	One relocatable symbol not found in the current program which may be followed by an absolute expression enclosed in parentheses.
ICTL	Blank	Two decimals in the form of B,E.
ISEQ	Blank	Blank or two decimal values in the form L, R.
ORG	Blank	Blank operand or an expression (A) optionally followed by two absolute expressions in the form A,B,C.
PRINT	Blank	Model 10 Disk System: One or two entries from DATA, NODATA, ON, OFF. Model 12 and Model 15: One to three entries from DATA, NODATA, GEN, NOGEN, ON, OFF.
SPACE	Blank	Blank or a decimal value.
START	Name or Blank	A self-defining value or blank.
TITLE	Name or Blank	A sequence of characters enclosed in apostrophes.
USING	Blank	A relocatable expression (V) and an index register (R) in the form V,R.

Appendix C: System/3 Assembler – Source Language Error Codes and Diagnostics

Code	Diagnostic	Explanation
N01	INVALID NAME LENGTH	Name field entry greater than six characters
N02	INVALID CHARACTER IN NAME	Name starts with non-alphabetic or contains an invalid character
N03	NAME NOT ALLOWED ON THIS INSTRUCTION	Name field entry not allowed on this instruction
N04	REFERENCE TO UNDEFINED SYMBOL	The referenced symbol is not defined in this program
N05	NAME MISSING FROM INSTRUCTION REQUIRING ONE	Name field entry missing from EQU instruction
N06	PREVIOUSLY DEFINED SYMBOL	Symbol has been previously defined in this program
N07	MODULE NAME MISSING	START instruction missing, or START instruction present but name field entry (module name) missing. Assembler assigns the default module name ASMOBJ.
O01	INVALID OPERATION CODE	Undefined operation field entry
O02	INVALID ORIGIN	Attempt to ORG to a value less than the initial value of the location counter
O03	INVALID OR ILLEGAL ICTL	Operand error on ICTL, or ICTL not the first statement in the program. (ICTL treated as last source statement in program)
O04	INVALID START INSTRUCTION	START instruction encountered after location counter is initialized
O05	LOCATION COUNTER ERROR	Location counter overflow (greater than 65536) or attempt to reference the location counter at 65536
O06	MISSING END STATEMENT	END statement missing from the program
P01	INVALID OPERAND DELIMITER	An operand field syntactical delimiter is either misplaced or missing
P02	INVALID OPERAND FORMAT	The operand field is not of the proper format for this instruction
P03	MISSING OPERAND	Operand field entry missing from instruction requiring one
P04	INVALID SYNTAX IN EXPRESSION	Violation of one or more expression syntax rules
P05	EXPRESSION VALUE TOO LARGE	Final expression value not in range -2^{16} to $2^{16}-1$
P06	INVALID OPERAND	One or more operand entries do not meet specifications for this instruction
P07	ARITHMETIC OVERFLOW	Intermediate expression value not in the range -2^{24} to $2^{24}-1$
P08	ADDRESSABILITY ERROR	Relocatable displacement outside the range of USING instruction
P09	REGISTER SPECIFICATION ERROR	Index register specification not 1 or 2
P10	INVALID CONSTANT	Error in constant specification on DC instruction
P11	INVALID CONSTANT TYPE	Data type specified on DC/DS is not valid
P12	INVALID DUPLICATION FACTOR	Error in duplication factor specification on DC/DS
P13	INVALID LENGTH SPECIFICATION	Error in length specification
P14	INVALID STATEMENT DELIMITER	The column following the statement field is not blank
P15	RELOCATABLE MULTIPLICATION	A relocatable term used in multiply operation
P16	RELOCATABILITY ERROR	A relocatable expression is used where an absolute expression is required, or an absolute expression is used where a relocatable expression is required
P17	INVALID SYMBOL	Invalid character in or invalid length of a symbol in the operand field
P18	INVALID SELF-DEFINING TERM	Error in the format of a self-defining term
P19	SELF-DEFINING VALUE TOO LARGE	Value of self-defining term is outside of range -2^{16} to 2^{16-1}
P20	INVALID IMMEDIATE FIELD	Immediate field not in range X'00' to X'FF'
P21	INVALID DISPLACEMENT	Absolute displacement not in range 0 to 255

Code	Diagnostic	Explanation
P22	INVALID EXTRN	Symbol is invalid or already defined in the program or subfield is invalid.
P23	TOO MANY ESL RECORDS	More than allowed number of EXTRN and ENTRY statements were found in the program. This count includes multiple EXTRNs and ENTRYs, ENTRYs with valid symbols which are not defined, and EXTRNs with valid symbols which are defined in the program. See *ESL Table Size* in *Part II. Programmer's Guide.*

Assembler subroutines can be linked to an RPG II program. The RPG II program passes parameters as it branches to the assembler subroutine. To write a subroutine that will be linked to an RPG II program the following rules must be used:

1. The name of the assembler subroutine must be SUBRxx. xx can be any valid alphabetic characters for user-written subroutines. (Numeric characters are reserved for IBM-supplied subroutines.) The name used must be the same as the name used in the RPG II program.

2. Upon entry to the assembler language subroutine, the address recall register (ARR) contains a pointer to the parameters which represent the fields to be referenced by the assembler subroutine. The return point to the RPG II program is the first byte after the parameters.

3. If the subroutine makes use of registers 1 and 2, the contents of these registers must be stored upon entry to, and restored before exit from, the subroutine.

USING FIELDS IN THE RPG II PROGRAM

When linkage is effected from RPG II to an assembler subroutine, three possible areas in the RPG II program can be referenced by the subroutine. They are: field, table or array, and indicator.

Referencing a Field in an RPG II Program

The following parameters (symbolic form of code generated by the compiler) are passed by RPG II when a field is to be referenced:

```
B    SUBRxx
DC   IL1'Field length -1'
DC   AL2(rightmost address of field)
```

Referencing a Table or Array in an RPG II Program

The following parameters (symbolic form of code generated by the compiler) are passed by RPG II when a table or array is to be referenced:

```
B    SUBRxx
DC   IL1'Entry length-1'
DC   AL2(leftmost address of table control field)
```

The subroutine can refer to the table or array defined in the RPG II program by utilizing the control field created for that table or array. This control field, one of which is created for each table or array built by the RPG II program, is in the following format:

Bytes	*Meaning*
1-2	Rightmost address of the first entry.
3-4	Rightmost address of the last entry.
5-6	Initialized to rightmost address of first entry; used at object time for rightmost address of the last looked-up entry of a table.
7-8	Length of an entry.

The subroutine can obtain the data retrieved from the last RPG II table LOKUP by using the address in bytes 5-6. To access the table or array itself, the address in bytes 1-2 must be used.

Data used by the subroutine must be left unpacked for the RPG II program.

Referencing an Indicator in an RPG II Program

The following parameters (symbolic form of code generated by the compiler) are passed by RPG II when an indicator is to be referenced:

```
B    SUBRxx

DC   XL1'00'

DC   XL1'Mask for the indicator'

DC   XL1'Displacement to the indicator from XR1'
```

Note: The parameters passed to the assembler subroutine are determined by the coding done in the RPG II program. For a description of this coding, see the *IBM System/3 RPG II Reference Manual,* SC21-7504, *IBM System/3 Model 6 RPG II Reference Manual,* SC21-7517, or *IBM System/3 Card System RPG II Reference Manual,* SC21-7500.

RPG II LINKAGE SAMPLE PROGRAM 1

In this sample program, the RPG II program links to the assembler language subroutine SUBRA (Figure 27). When control is returned to the RPG II program, the character 'A' will have been moved into the field in the RPG II program.

RPG II LINKAGE SAMPLE PROGRAM 2

In this sample program, the RPG II program links to the assembler subroutine SUBRB (Figure 28). The first parameters passed reference a table. The second parameters reference an indicator. The subroutine refers to both sets of parameters. The subroutine first tests the indicator in the RPG II program. If the indicator is off, control is returned to the RPG II program. If the indicator is on, a character 'C' is moved into the last looked up entry in the table. When control is returned to the RPG II program, it checks for a 'C' in the table.

I/O SUBROUTINES

Subroutines that support input or output devices can also be linked to an RPG II program. These subroutines are commonly referred to as RPG II SPECIAL subroutines.

Linkage for I/O Subroutines

The following linkage is generated by RPG II to communicate with the user-supplied I/O subroutine.

1. DTF (define-the-file) format:

Bytes	*Description*
0	Device code (X'00')
1	UPSI mask
2-3	Attributes
4-5	Reserved for data management
6-7	Address of next DTF
8-B	Reserved for data management
C-D	Logical record address
E	Completion code X'42' = End-of-file X'41' = Controlled cancel (not recognized by Model 10 card system) X'40' = Normal completion (not recognized by Model 10 card system)
F	Operation X'C0' = Get and put (model 10 card system only) X'80' = Get X'40' = Put X'20' = Update X'10' = Close
10-11	Input I/O address
12-13	Output I/O address
14-15	Block length
16-17	Record length
18-19	Address of array DTT if array linkage is used

The address of byte 0 of the DTF will be passed to the I/O subroutine in index register 2. Bytes 0-3, 6-7, C-D, and 10-17 are filled in by RPG II at compile time. Byte E, completion code, is inserted by the I/O subroutine when control is returned to RPG II. Byte F, the operation byte, is inserted at object time. The information in bytes 0 and 4-B must be available, unchanged at close time, for data management.

The DTT (define-the-table) is used for array linkage. DTT format:

Bytes	*Description*
0-1	Address of rightmost byte of the first element of the array.
2-3	Address of rightmost byte of the last element of the array.
4-5	RPG last LOKUP element.
6-7	Length of array element.

2. The I/O subroutine must save and restore the registers altered in the routine. Control should be returned to the address in the address recall register (ARR).

Note: The combined get and put operation code, X'C0', is utilized by the System/3 Model 10 Card System only. The System/3 Model 10 Disk System, System/3 Model 12, and System/3 Model 15 use alternate get and put operations to accommodate combined files. When coding an I/O subroutine to be used on either system, be certain to consider this fact.

When an input operation is done, the I/O subroutine must move the address of the physical buffer currently being used to the logical buffer address location in the DTF (bytes C-D). In the Model 10 Card System, address bytes 10-11 will be the same as bytes C-D (one physical buffer).

When an output operation is requested, the I/O subroutine must move the data from the logical buffer (address in bytes C-D of the DTF) to the physical buffer (address in bytes 12-13 of the DTF). The two addresses are the same in the Model 10 Card System. Bytes 0-B are unused in the Model 10 Card System.

The I/O subroutine must do its own open when the first call to it is issued. It must also do its own close to the file on a close call.

If a dual I/O is requested, the second area will be immediately behind the first (Model 10 Disk System, Model 12, and Model 15 only).

The I/O subroutine cannot be overlaid in the Model 10 Disk System, Model 12, and Model 15.

Sequential processing only is supported.

When an I/O subroutine issues a halt, three halts should be displayed as follows:

1. The first halt issued should be the FF halt reserved by RPG II for SPECIAL I/O subroutine usage.
2. The second halt should be the last two digits of the subroutine name.
3. The third halt may be any valid halt that can be displayed.

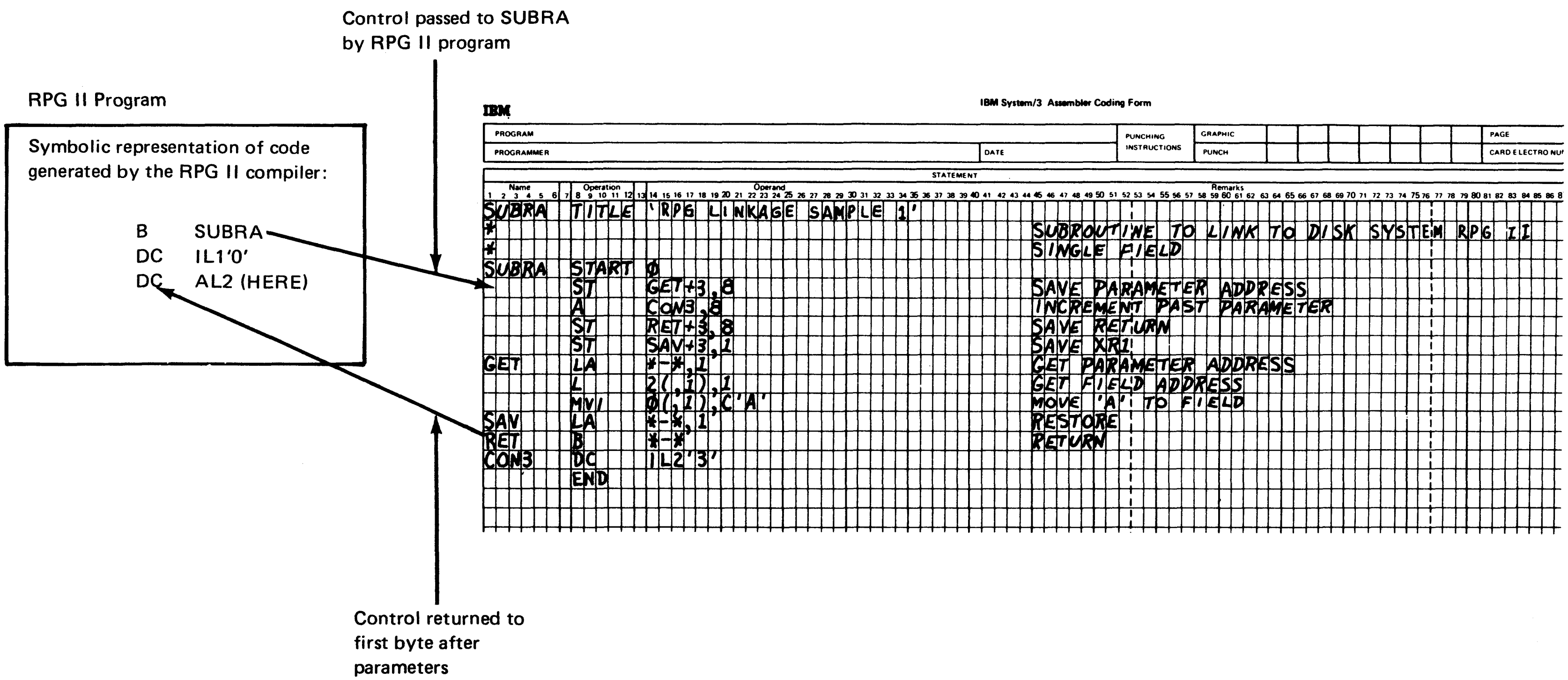


Figure 27. Assembler Language Subroutine (SUBRA) for Sample Program 1

Control passed to SUBRB by RPG II program

RPG II Program

Symbolic representation of code generated by the RPG II compiler:

```
      B     SUBRB                                          (3)
(1) { DC    IL1'0'
    { DC    AL2 (leftmost address of table control field)
    ( DC    XL1'00'
(2) { DC    XL1'80'
    ( DC    XL1'31'
```

(1) Parameters passed for a table

(2) Parameters passed for an indicator

(3) Control field for table

```
DC    AL2 (address of first entry)
DC    AL2 (address of last entry)
DC    AL2 (address of last looked-up entry [TABB])
DC    IL2'1' (length of entry)
```

IBM System/3 Assembler Coding Form

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC	PAGE
PROGRAMMER	DATE		PUNCH	CARD ELECTRO NU

```
SUBRB  TITLE  'RPG LINKAGE SAMPLE 2'
*                                        SUBROUTINE TO LINK TO DISK SYSTEM RPG II.
*                                        TABLE,INDICATOR
SUBRB  START  Ø
       ST     GET+3,ARR                  SAVE PARAMETER ADDRESS
       A      CON6,ARR                   INCREMENT TO RETURN
       ST     RET+3,ARR                  SAVE RETURN
       ST     SAVE+3,2                   SAVE XR2
GET    LA     *-*,2                      GET PARAMETER ADDRESS
       MVC    TEST+2(2),5(,2)            MOVE IN MASK AND DISPLACEMENT
TEST   TBN    *-*(,1),*-*                TEST INDICATOR
       JF     SAVE                       INDICATOR OFF
       L      2(,2),2                    GET CONTROL FIELD ADDRESS
       L      5(,2),2                    GET LOOK UP ADDRESS
       MVI    Ø(,2),C'C'                 MOVE IN CHARACTER 'C'
SAVE   LA     *-*,2                      RESTORE
RET    B      *-*                        RETURN
CON6   DC     IL2'6'
ARR    EQU    8
       END
```

Control returned to first byte after parameters

Figure 28. Assembler Language Subroutine (SUBRB) for Sample Program 2

LIBRARY DECK GENERATOR PROGRAM (MODEL 10 ONLY)

The System/3 Model 10 Card System user can write assembler language subroutines to be used as SPECIAL or EXIT routines in an RPG II program. These assembler routines, however, cannot be inserted directly into the RPG II compiler. The assembler language subroutine must first be assembled by the System/3 Model 10 Disk System Basic Assembler and then translated by the Library Deck Generator (LDG) program before it can be placed in the RPG II compiler.

The entire operation, from writing an assembler subroutine to selection of that subroutine by the IBM System/3 Model 10 Card System RPG II compiler is outlined as follows:

1. The assembler subroutine is written by the programmer. If standard control cards supplied by the LDG program are not being used, the programmer must also code control cards for the subroutine.

2. The assembler subroutine is assembled on the System/3 Model 10 Disk System by the Basic Assembler.

3. The LDG program is read into System/3 Model 10 Disk System storage. The *** parameter card, assembler subroutine object deck, and blank cards are placed in the MFCU.

4. The LDG program produces a deck of cards, containing the subroutine, which can be placed in the RPG II compiler. The deck produced by the LDG program contains the following:

   Header card
   Control cards
   Text
   Q-card
   End card

5. The deck produced by the LDG program may now be placed in the RPG II compiler deck. When an RPG II program is compiled, this subroutine will be selected, when required, just as any other compiler subroutine.

The following material describes the information needed to use an assembler language subroutine in an RPG II program. This material is divided into four major sections:

Writing the assembler language program
Running the LDG program
Output of the LDG program
Example of a SPECIAL subroutine

Writing the Assembler Language Program

The following information must be considered when the assembler language program is written.

Title Instruction

The name field of the TITLE instruction must contain 00GEB in columns 1-5.

Control Cards

Control cards are needed for every assembler language subroutine. Control cards contain code, executed during compile time, which determines whether the subroutine should be included as part of the program being compiled. Library routines are selected only when the execution of a control card determines they are needed. In addition, control cards are needed to ensure that the entry point for the subroutine is placed in the proper location in core for the RPG II compiler to find and use it.

There are two ways to get the control cards you need. In some cases, you will need to code them yourself; in others standard control cards are supplied by the LDG program. If your subroutine is to be used as a normal SPECIAL or EXIT routine, the LDG program will supply three control cards. See Figure 29 for samples of these. When these control cards are provided, a SPECIAL routine is selected if bytes 12-13 of the file description compression matches the identification characters of the routine, and if the SPECIAL device code B'0xxx1010' is present in byte 16 of the same file description compression. EXIT routines are selected if the identifier in the library routine is the same as an entry in the symbol table (bytes 3-4) and if byte 2 of the same entry contains bit configuration 11100000. When these decks are selected, the address of the entry point of associated object code is placed in the symbol table entry, bytes 3-4 for an EXIT reference and/or bytes 8-9 of the file description compression for a SPECIAL reference.

You must code control cards for your subroutine when:

- The subroutine is not a SPECIAL or EXIT routine.
- The subroutine needs a function not provided by the standard control cards.

The following paragraphs describe several compiler resident routines which can be used by programmer coded control cards.

Coding Control Cards

There are three types of control cards each identified by a special character in column 1. Each type performs a different function:

- Cards with a J in column 1 (J-cards) are usually used to control the selection of a routine for an object program. They also place the routine entry address in compile time storage for use by the RPG II compiler.
- Cards with a K in column 1 (K-cards) are used only when one routine from a set of related routines is to be used in any job. A J card will determine if any of these routines are needed and if so will start the scan for K cards which in turn control selection of the proper routine.
- Cards with an L in column 1 (L-cards) are used to pass information from RPG II compile time core to a subroutine or vice versa. They are executed only if the deck in which they appear has been selected for use with the current program.

Control card identification characters must be defined for assembly at X'0000' and are placed in column 1 of control cards. The only allowable characters are J, K, L, and blank. There should be one non-blank control card identifier character for each block of code for a control card. The blank is used as a delimiter between control card strings.

For example, DCb̸b̸b̸b̸ CLI0'JKLLb̸Lb̸Lb̸L' shows identifiers for seven control cards and four control card strings. The first is a 4-card string with identifiers 'JKLL' used. The others are single card strings, each of which has an 'L' identification.

LDG identifies the control cards and assigns one control card identification character to each one. The control card strings are merged with the text cards for the routine functional code in the following manner. The first control card string is merged in front of the text, and one additional control card string is merged into the text cards where there is a break in the text caused by a DS or an ORG which changes the location counter.

Each control card must contain executable code. Control cards are coded in the order needed for the purposes described above. Each must begin at X'0017'; therefore, an ORG to 23 or X'0017' must precede the code for each card.

Your control cards must contain instructions for calculating the address at which your subroutine will be loaded. To calculate the true entry address, use the current relocation factor described here.

Label	*Address*	*Function*
RELOCF	X'030C' to X'030D'	Contains the current relocation factor. Is modified when the end card of the selected deck is encountered or J1EAA1 is entered.

See Figure 29, Part 1, found at the end of this section, for an example of the use of the current relocation factor.

The following paragraphs describe several compiler resident routines which can be used by programmer coded control cards.

J-Card Scan Routine reads the library deck until a J-card is encountered. The routine has three entry points.

Label	*Address*	*Function*
J3EAA1	X'031A'	Scans for J-card. When one is found, control is passed to that card. All other cards are ignored.
J2EAA1	X'3014'	Clears X'00E0' to X'00FF' and X'007C' to X'007F' to hex zeroes then scans for J-card as J3EAA1.
J1EAA1	X'030E'	Resets the relocation factor to the next object address and performs as J2EAA1.

K-Card Scan Routine has one entry point.

Label	*Entry Point*	*Function*
K1EAB1	X'0320'	Scans for K-card. When one is found, control is passed to that card. All other cards except J-cards are ignored. If a J-card is found, a halt '40' is executed.

Relocate Deck Routine has one entry point.

Label	*Entry Point*	*Function*
R1EAC1	X'032C'	Initiates or continues relocation of the current deck. Will recognize and execute L-cards and reorganize and print Q-cards. Exits to J1EAA1 when end card is encountered.

Scan File Description Compressions Routine has two entry points. This routine steps through the file description compressions. It returns a pointer to the next compression in register 2. If the condition code is high, the pointer is valid. Any other condition indicates the pointer is invalid.

Label	*Entry Point*	*Function*
F1EAE1	X'0338'	Initializes pointer to first file description compression and sets condition code.
F2EAE1	X'033E'	Points register 2 to the next compression and sets the condition code. (Register 2 need not be pointing to the last compression.)

Scan Extension Compressions Routine has two entry points and steps through the extension compressions and returns a pointer to the next compression in register 2. A high condition code indicates a valid pointer. Any other condition code indicates an invalid (undefined) pointer.

Label	*Entry Point*	*Function*
E1EAF1	X'0344'	Initializes pointer to first extension compression and sets condition code.
E2EAF1	X'034A'	Points register 2 to the next compression and sets condition code. (Register 2 need not point to last compression.)

Text Handling Routine builds up full text card in storage and, when a card is full, punches that card. The area from X'0080' to X'00DF' is the location of the punch buffer and this must be considered when using this area of core.

Label	*Entry Point*	*Function*
BKEAH1	X'0350'	Forces any partial text card to be punched.
STXLA1	X'035C'	Accepts a string of text to be added to the current text immediately following the last text passed. Requires a 1-byte parameter following the branch. Parameter contains a displacement relative to register 1 to the length byte of the text being passed. The text string should be preceded by this length byte which contains the length of text.

Wait On Punch Busy Routine:

Label	*Entry Point*	*Function*
WTPUN1	X'0362'	Returns when the previous punch operation has been successfully completed and the buffer is not busy.

Title of Subroutine

The title of the routine must be a defined constant to be loaded starting at X'0000'. It must be equal to or less than 80 characters in length. This title is printed on the RPG II compiler listing with the address of the entry point of the routine if it is selected at compile time.

Routine Functional Code

This code must be assembled starting at X'0000'. The code must contain a break in continuity (a DS or an ORG which changes the location counter value) where control cards are to be inserted.

Assembling the Subroutine

The assembler subroutine is assembled by the Model 10 disk system basic assembler. The OCL considerations for assembly are discussed in *Section II: Programmer's Guide* under the headings *OPTIONS Statement* and *OCL Statements For Assembler.*

An OPTIONS card must be used to successfully assemble the subroutine.

Running the LDG Program

The following paragraphs describe a special parameter card that must be used with the assembler deck, the OCL required to load the LDG program, and error conditions that may result.

Library Deck Generator Parameter Card (***)

A parameter card must precede the assembler generated object deck to provide the LDG program with information regarding output. Entries for the parameter card are as follows:

Columns	*Entry*	*Explanation*
1-3	***	Three asterisks identify a parameter card.
4-9	SUBRxx	These characters identify the subroutine. Substitute any two characters for xx – the second may be blank, but the first must not. Note that the LDG program will not diagnose an error in these columns.
10	, (comma)	Required.
11	S	Standard control cards will be provided by the LDG program for the subroutine identified by the characters found in columns 8-9 of this parameter card. The title, also extracted from this parameter card, will be assigned to the subroutine. The entry point of the routine must be the first byte of the routine. GEB will be forced as module identifier.
	N	Non-standard control cards will be supplied by the user as will identification characters and title. (The format of this material may be found in Figure 29.) If N is specified, the title specified in this parameter card is ignored. Thus, if N is used, columns 21-96 may be left blank.
12	, (comma)	Required.
13	D	Default values for component version, modification level, and indication of complete or partial deck replacement for header card are provided by the LDG program.
	G	Default values are not assumed. The user must provide them in columns 15-19.
14	, (comma)	Required if column 11 contains an S or column 13 a G.
15-16	VV	Two numbers indicating the component version.
17-18	MM	Two numbers indicating modification level.
19	0 (zero)	Partial deck replacement for header card.
	1	Complete deck replacement for header card.
20	, (comma)	Required only if column 13 contains a G and column 11 an S.
21-96	Subroutine title	If column 11 contains an N, the title is not required. If column 13 contains a D, the title of the subroutine must begin in column 15.

Examples:

```
***SUBRA ,N,D
```

User will supply all control cards, identifying characters, and title for subroutine 'Ab'.

```
***SUBRBB,S,G,Ø2ØØ1,SPECIAL ROUTINE BB
```

Library Deck Generator will supply standard control cards which will be used for selection of subroutine BB. The title will be printed on the 4th tier of the cards and on the compiler listing. The values given in columns 15-19 will be used on the header card. The component version (02) will go in columns 59-60 of the header card, the modification level (00) will go in columns 31-32, and deck replacement indicator (1) will be placed in column 85.

Loading the LDG Program

```
// LOG PRINTER
// LOAD $ASLDG,R1
// RUN
***SUBR (PARAMETER CARD)
      {
      {
    ASSEMBLER OBJECT PROGRAM
      {
      {
/*
```

Error Conditions

Several errors are considered to be terminal. If terminal errors occur, the card image is printed, the error message is printed, the deck is run through to the '/*' card, and a C halt is displayed. When this halt is reset, processing is discontinued by the end-of-job routine.

If the error is not terminal, the card image is printed, an error message is printed, and a C halt is displayed. The program is restartable, however, and processing will continue.

Following is a list of error messages generated by this phase. An asterisk (*) preceding the number indicates which are warning errors.

1. Number of control cards generated incorrect.
2. Length of control card text, too great for one card.
3. Card sequence incorrect.
4. Title too long or the first text is contiguous.

*5. First control card character may not be blank.

6. Not enough breaks for control strings.

*7. More breaks than control strings.

*8. Last text not at highest address expected.

9. Improper card in deck.
10. End card out of sequence.
11. Invalid control card identification.
12. First object card must be an ESL card.
13. Insufficient core for control card storage.
14. Invalid entries on *** control card.

15. / card or *** card out of sequence.

*16. GEB not used as module identifier.

17. *** card required before object deck.
18. Too many control card identifiers specified or invalid sequence.

Output of the LDG Program

The header card in stacker 2 should be placed in front of the remainder of the output deck in stacker 3. Insert the subroutine deck in the RPG II Compiler deck using the Program Maintenance Program. The subroutine deck must have GEB in columns 91-93.

Example

Figure 29 is an example of a SPECIAL subroutine. This sample program can be used as a base for any SPECIAL or EXIT subroutine. The only changes required are modifying the subroutine identification characters, entry point, label, and routine title. Areas of change are outlined in the sample listing. Control cards are created for you.

```
00GEB  ANY TITLE DESIRED MAY BE USED

ERR LOC  OBJECT CODE       ADDR STMT SOURCE STATEMENT

                              2 * ******************************************************************** *        00020000
                              3 *                                                                      *        00030000
                              4 *    THIS IS A SAMPLE CODING FOR THE CONTROL CARDS FOR A 'SPECIAL'     *        00040000
                              5 *                                                                      *        00050000
                              6 *    DEVICE REFERENCED IN AN RPG PROGRAM. ALL LABELS WHICH WILL        *        00060000
                              7 *                                                                      *        00070000
                              8 *    NEED TO BE MODIFIED FOR A PARTICULAR PROGRAM HAVE LABELS          *        00080000
                              9 *                                                                      *        00090000
                             10 *    STARTING WITH THE CHARACTER '#'. THIS DECK IS IN THE FORMAT       *        00100000
                             11 *                                                                      *        00110000
                             12 *    REQUIRED BY THE LIBRARY DECK GENERATOR.                           *        00120000
                             13 *                                                                      *        00130000
                             14 *    THESE CONTROL CARDS MAY BE USED FOR ANY SPECIAL OR EXIT           *        00140000
                             15 *                                                                      *        00150000
                             16 *    SUBROUTINE.                                                       *        00160000
                             17 *                                                                      *        00170000
                             18 * ******************************************************************** *        00180000


                             20 * ******************************************************************** *        00200000
                             21 *                                                                      *        00210000
                             22 *      STANDARD LABELS AND LABELS USED TO LINK TO THE LIBRARY          *        00220000
                             23 *                                                                      *        00230000
                             24 *         SELECT ROUTINE AND RPG COMPILER COMMUNICATIONS AREA          *        00240000
                             25 *                                                                      *        00250000
                             26 * ******************************************************************** *        00260000
    0000                     28 START  START 0               PROGRAM SHOULD BE STARTED AT 0                     00280000
                       0001  29 XR1    EQU   1               STANDARD LABEL FOR INDEX REGISTER 1                00290000
                       0002  30 XR2    EQU   2               STANDARD LABEL FOR INDEX REGISTER 2                00300000
                       0008  31 ARR    EQU   8                                  ADDRESS RECALL REG              00310000

                       030D  33 RELOCF EQU   START+X'030D'   RELOCATION FACTOR FOR CURRENT DECK                 00330000
                       030E  34 J1EAA1 EQU   START+X'030E'   ENTRY POINT TO RESET RELOCATION                    00340000
                             35 *                              FACTOR AND SCAN TO NEXT 'J' CARD                 00350000
                       031A  36 J3EAA1 EQU   START+X'031A'   ENTRY TO SCAN TO NEXT 'J' CARD WITH-               00360000
                             37 *                              OUT RESETTING RELOCATION FACTOR                  00370000
                       032C  38 R1EAC1 EQU   START+X'032C'   ENTRY POINT TO INITIATE OR CONTINUE                00380000
                             39 *                              RELOCATION OF THIS DECK                          00390000
                       0338  40 F1EAE1 EQU   START+X'0338'   ENTRY POINT TO INITIATE THE SCAN OF                00400000
                             41 *                              THE FILE DESCRIPTION COMPRESSIONS                00410000
                       033E  42 F2EAE1 EQU   START+X'033E'   ENTRY POINT TO CONTINUE FILE DISC.                 00420000
                             43 *                              COMP. SCAN                                       00430000
                             44 *                                 BOTH OF THE PREVIOUS ENTRIES                  00440000
                             45 *                                 RETURN A POINTER IN XR2 AND A                 00450000
                             46 *                                 CONDITION CODE 'HIGH' IF THAT                 00460000
                             47 *                                 POINTER IS VALID                              00470000

                       028C  49 COMMON EQU   START+X'028C'   START OF THE RPG COMPILER                          00490000
                             50 *                              COMMUNICATIONS AREA                              00500000
                       02E6  51 ENDCOR EQU   COMMON+90       HOLDS LAST ADDRESS IN MEMORY -FIRST                00510000
                             52 *                              BYTE USED FOR SYMBOL TABLE -                     00520000
                       02EA  53 ENDST  EQU   COMMON+94       HOLDS LAST ADDRESS USED FOR SYMBOL                 00530000
                             54 *                              TABLE.                                           00540000
```

Figure 29 (Part 1 of 4). Sample Coding for SPECIAL Device

```
ERR LOC  OBJECT CODE      ADDR STMT SOURCE STATEMENT
                                56 * ****************************************************************** *   00560000
                                57 *                                                                    *   00570000
                                58 *      THE FOLLOWING IS A SKELETON FOR A FILE DESCRIPTION            *   00580000
                                59 *                                                                    *   00590000
                                60 *        COMPRESSION                                                 *   00600000
                                61 *                                                                    *   00610000
                                62 * ****************************************************************** *   00620000

    0000                   0000 64 FCFG   DS    CL1                FLAG BYTE FOR COMP. ALWAYS X'FF'        00640000
    0001                   0002 65        DS    CL2                OUTPUT BUFFER @                         00650000
    0003                   0004 66        DS    CL2                INPUT  BUFFER ADDRESS                   00660000
    0005                   0006 67        DS    CL2                PRINT  BUFFER ADDRESS                   00670000
    0007                   0008 68 FCENT@ DS    CL2                IOCS ENTRY POINT ADDRESS                00680000
    0009                   0009 69        DS    CL1                FLAG BYTE                               00690000
    000A                   000A 70        DS    CL1                FLAG BYTE                               00700000
    000B                   000C 71 FCIDNT DS    CL2                HOLDS IDENT FOR SPECIAL ROUTINE         00710000
    000D                   000E 72        DS    CL2                EXTERNAL INDICATOR ASSIGNMENT           00720000
    000F                   000F 73 FCDVA  DS    CL1                DEVICE CODE B'0XXX1010' FOR SPECIAL     00730000
    0010                   0010 74        DS    CL1                BLOCKING FACTOR                         00740000
    0011                   0011 75        DS    CL1                RECORD LENGTH                           00750000


                                77 * ****************************************************************** *   00770000
                                78 *                                                                    *   00780000
                                79 *      THE FOLLOWING IS A SKELETON FOR A SYMBOL TABLE ENTRY          *   00790000
                                80 *                                                                    *   00800000
                                81 * ****************************************************************** *   00810000

    0012                   0012 83 STLEN  DS    CL1                LENGTH FOR FIELD ENTRY                  00830000
    0013                   0013 84 STFLAG DS    CL1                FLAG BYTE SPECIAL NEEDS B'        '     00840000
    0014                   0015 85 STIDNT DS    CL2                IDENT FOR SPECIAL C'##' HOLDS ENTRY     00850000
                                86 *                                 POINT AFTER SELECTION                 00860000


                                88 * ****************************************************************** *   00880000
                                89 *                                                                    *   00890000
                                90 *      THE FOLLOWING DC CONTAINS THE ID'S FOR THE CONTROL CARDS      *   00900000
                                91 *                                                                    *   00910000
                                92 * ****************************************************************** *   00920000


    0000                        94        ORG   0                                                       00940000
    0000 D1D1D1            0002 95        DC    CL3'JJJ'           THREE CONTROL CARDS ALL WITH IDENT      00950000
                                96 *                               'J' AND INSERTED IN FRONT OF THE        00960000
                                97 *                                 DECK                                  00970000
                                99 * ****************************************************************** *   00990000
                               100 *                                                                    *   01000000
                               101 *      THIS CONTROL CARD SCANS THE 'F' COMPRESSIONS FOR REFERENCE TO *   01010000
                               102 *                                                                    *   01020000
                               103 *       '##'  IF FOUND IT SETS THE FLAG BYTE AT X'007B' TO X'FF'.    *   01030000
                               104 *                                                                    *   01040000
                               105 *       IF EITHER FOUND OR NOT FOUND IT STARTS THE SCAN FOR THE NEXT *   01050000
                               106 *                                                                    *   01060000
                               107 *       CONTROL CARD.                                                *   01070000
                               108 *                                                                    *   01080000
                               109 * ****************************************************************** *   01090000


    0017                       111        ORG   X'0017'                  REQUIRED FOR EACH CONTROL CARD    01110000
                          007B 112 FLG    EQU   START+X'7B'              AREA FROM X'7B' TO X'FF' IS       01120000
                               113 *                                       USABLE FOR WORKING STORAGE      01130000
                               114 *                                       THIS BYTE USED TO FLAG IF       01140000
                               115 *                                       ROUTINE IS REFERENCED ON 'F'    01150000
                               116 *                                       SPECIFICATIONS                  01160000
                          0000 117        USING START,XR1                VALID AT ENTRY TO ANY CTL. CARD   01170000
    0017 7C 00 7B              118        MVI   FLG(,XR1),X'00'          INITIALIZE FLAG FOR NOT USED      01180000
                               119 *                                       ON FILE DESCRIPTION SPECS.      01190000
    001A 4E 01 43 030D         120        ALC   #ENTRY(2,XR1),RELOCF     CALCULATE TRUE ENTRY ADDRESS      01200000
    001F C0 87 0338            121        B     F1EAE1                   INITIATE SCAN OF 'F' COMPS.       01210000
                          0000 122        USING FCFG,XR2                 VALID UPON RETURN FROM F1EAE1     01220000
    0023 6D 01 45 0C           123 SPCA1  CLC   #IDENT(2,XR1),FCIDNT(,XR2) IS THE IDENT THE RIGHT CHAR     01230000
    0027 B8 0A 0F              124        TBN   FCDVA(,XR2),B'00001010'    AND IS DEVICE CODE THAT FOR     01240000
    002A B9 85 0F              125        TBF   FCDVA(,XR2),B'10000101'    'SPECIAL'                       01250000
    002D F2 96 07              126        JC    SPCA2,X'96'              IF THIS IS NOT THE RIGHT COMP, JUMP 01260000

    0030 7C FF 7B              128        MVI   FLG(,XR1),X'FF'          SET FLAG TO INDICATE USED ON      01280000
                               129 *                                       FILE DESCRIPTION SPECS.         01290000
    0033 9C 01 08 43           130        MVC   FCENT@(2,XR2),#ENTRY(,XR1) MOVE ENTRY ADDRESS TO THE       01300000
                               131 *                                         FILE DESCRIPTION COMP.        01310000
    0037 C0 87 033E            132 SPCA2  B     F2EAE1                   ELSE SCAN TO NEXT COMP            01320000
    003B D0 84 23              133        BH    SPCA1(,XR1)              IF POINTER STILL OK LOOP          01330000
    003E C0 87 031A            134        B     J3EAA1                   GET NEXT 'J' CARD                 01340000
                               135 *                                       THIS ENTRY WILL NOT CLEAR THE   01350000
                               136 *                                       BYTE AT FLG.                    01360000


    0042 0000             0043 138 #ENTRY DC    AL2(SUBR##)              ENTRY POINT ADDR. TO BE RELOCAT   01380000
    0044 7B7B             0045 139 #IDENT DC    CL2'##'                  TWO CHARACTER IDENT FOR ROUTINE   01390000

                          0002 141        DROP  XR2                                                        01410000
```

Identify your subroutines by replacing these # signs with identifying characters.

Figure 29 (Part 2 of 4). Sample Coding for SPECIAL Device

```
ERR LOC  OBJECT CODE        ADDR STMT SOURCE STATEMENT

                                 143 * ******************************************************************** *       01430000
                                 144 *                                                                      *       01440000
                                 145 *      THIS CONTROL CARD DETERMINES THE END ADDRESS TO BE USED         *       01450000
                                 146 *                                                                      *       01460000
                                 147 *      IN THE SEARCH OF THE SYMBOL TABLE DONE BY THE NEXT CONTROL      *       01470000
                                 148 *                                                                      *       01480000
                                 149 *      CARD.                                                           *       01490000
                                 150 *                                                                      *       01500000
                                 151 * ******************************************************************** *       01510000


                            007D 153 END@    EQU    START+X'7D'              THIS TWO BYTE AREA WILL HOLD           01530000
                                 154 *                                       THE ADDRESS TO CONTROL THE             01540000
                                 155 *                                       SYMBOL TABLE SCAN. IT WILL BE          01550000
                                 156 *                                       THE ADDRESS OF THE END OF THE          01560000
                                 157 *                                       SYMBOL TABLE OR THE FIRST              01570000
                                 158 *                                       TABLE ADDRESS TABLE POINTER            01580000
                                 159 *                                       WHICH EVER IS HIGHEST                  01590000

    0017                         161         ORG    X'0017'                                                         01610000
    0017 4C 01 7D 02EA           162         MVC    END@(2,XR1),ENDST        INITIALIZE END ADDRESS TO END          01620000
                                 163 *                                         OF SYMBOL TABLE                      01630000
    001C C2 02 FFFC              164         LA     X'FFFC',XR2              INITIALIZE XR2 TO NEGATIVE 4           01640000
    0020 36 02 02E6              165         A      ENDCOR,XR2               POINT XR2 TO FIRST ENTRY IN            01650000
                                 166 *                                         SYMBOL TABLE                         01660000
                            0011 167         USING STLEN-1,XR2                                                      01670000
    0024 B9 18 02                168         TBF    STFLAG(,XR2),X'18'       TEST IF ENTRY FOR TABLE OR             01680000
                                 169 *                                         ARRAY                                01690000
    0027 F2 10 04                170         JT     SPCB0                    IF NEITHER --> JUMP                    01700000
    002A 6C 01 7D 04             171         MVC    END@(2,XR1),STIDNT(,XR2) ELSE RESET THE END ADDRESS             01710000
    002E C0 87 031A              172 SPCB0   B      J3EAA1                   GO GET NEXT CARD                       01720000
                            0002 173         DROP   XR2                                                             01730000
                                 175 * ******************************************************************** *       01750000
                                 176 *      THIS CONTROL CARD CHECKS THE SYMBOL TABLE FOR REFERENCES FROM   *       01760000
                                 177 *                                                                      *       01770000
                                 178 *      CALCULATIONS. IF REFERENCED THERE OR ON 'F' SPECS RELOCATION    *       01780000
                                 179 *                                                                      *       01790000
                                 180 *      OF THE DECK IS INITIATED                                        *       01800000
                                 181 *                                                                      *       01810000
                                 182 * ******************************************************************** *       01820000


    0017                         184         ORG    X'0017'                  START OF CONTROL CARD TEXT             01840000
    0017 4E 01 51 030D           185         ALC    #ENT(2,XR1),RELOCF       CALCULATE ENTRY ADDRESS                01850000
    001C 4C 01 30 02E6           186         MVC    SPCB2+3(2,XR1),ENDCOR    INITIALZE LA BELOW                     01860000
    0021 5E 01 30 55             187 SPCB1   ALC    SPCB2+3(2,XR1),STSTEP(,XR1) STEP BACK TO NEXT ENTRY             01870000
    0025 4D 01 30 02EA           188         CLC    SPCB2+3(2,XR1),ENDST     CHECK FOR END OF SYMBOL TABLE          01880000
    002A F2 82 18                189         JL     SPCB3                    IF BEYOND END --> JUMP                 01890000
    002D C2 02 0000              190 SPCB2   LA     *-*,XR2                  POINT TO ENTRY                         01900000
                            0011 191         USING STLEN-1,XR2                                                      01910000
    0031 9D 01 04 53             192         CLC    STIDNT(2,XR2),#IDN(,XR1) IS THE IDENT CORRECT AND               01920000
    0035 B8 E0 02                193         TBN    STFLAG(,XR2),B'11100000'  THE ENTRY FOR AN EXIT LABEL           01930000
    0038 D0 96 21                194         BC     SPCB1(,XR1),X'96'        IF NOT CORRECT ENTRY --> LOOP          01940000
    003B 9C 01 04 51             195         MVC    STIDNT(2,XR2),#ENT(,XR1) ELSE MOVE IN ENTRY POINT               01950000
    003F BA 01 02                196         SBN    STFLAG(,XR2),B'00000001' SET FLAG FOR ROUTINE FOUND             01960000
    0042 F2 87 07                197         J      SPCB4                    START RELOCATION OF ROUTINE            01970000
    0045 7D FF 7B                198 SPCB3   CLI    FLG(,XR1),X'FF'          WAS ROUTINE REFERENCED FROM            01980000
                                 199 *                                         FILE DESCRIPTION  SPECS. ?           01990000
    0048 C0 01 030E              200         BNE    J1EAA1                   NO - UNUSED SCAN TO NEXT DECK          02000000
    004C C0 87 032C              201 SPCB4   B      R1EAC1                   YES - USED AS SPECIAL RELOCATE         02010000


    0050 0000               0051 203 #ENT    DC     AL2(SUBR##)              ENTRY POINT FOR RELOCATING             02030000
    0052 7B7B               0053 204 #IDN    DC     CL2'##'                  IDENTIFICATION                         02040000


    0054 FFFC               0055 206 STSTEP  DC     IL2'-4'                  NEGATIVE LENGTH OF SYMBOL              02060000
                                 207 *                                         TABLE ENTRY                          02070000
```

Replace these # signs with the characters identifying your subroutine.

Figure 29 (Part 3 of 4). Sample Coding for SPECIAL Device

```
ERR LOC  OBJECT CODE      ADDR STMT SOURCE STATEMENT
                               209 * ******************************************************************* *      02090000
                               210 *                                                                     *      02100000
                               211 *     THE FOLLOWING DC CONTAINS THE PROGRAM TITLE TO BE PRINTED       *      02110000
                               212 *                                                                     *      02120000
                               213 *       ON THE RPG LISTING AND SHOULD BE CHANGED TO REFLECT THE       *      02130000
                               214 *                                                                     *      02140000
                               215 *       NAME OF THE SUBROUTINE.                                       *      02150000
                               216 *                                                                     *      02160000
                               217 * ******************************************************************* *      02170000

    0000                       219       ORG   0                          SIGNALS START OF TITLE                02190000


    0000 E2D7C5C3C9C1D340 001D 221       DC    CL30'SPECIAL I/O ROUTINE ##'                                     02210000
    0008 C961D64OD9D6E4E3      221
    0010 C9D5C5407B7B4040      221
    0018 404040404040          221
```

Replace these # signs with the characters identifying your subroutine.

```
                               223 * ******************************************************************* *      02230000
                               224 *                                                                     *      02240000
                               225 *     THE FOLLOWING CODE REPRESENTS THE FUNCTIONAL CODE FOR THE       *      02250000
                               226 *                                                                     *      02260000
                               227 *     USER ROUTINE. THE ABOVE CONTROL CARDS ASSUME THE ENTRY POINT    *      02270000
                               228 *                                                                     *      02280000
                               229 *     IS AT SUBR##.  THE ENTRY POINT IS UNIQUE TO EACH SUBROUTINE.    *      02290000
                               230 *                                                                     *      02300000
                               231 *     THE ENTRY POINT IS THE LABEL ON THE ROUTINE CODE, NOT THAT      *      02310000
                               232 *                                                                     *      02320000
                               233 *     ON THE START CARD.                                              *      02330000
                               234 *                                                                     *      02340000
                               235 * ******************************************************************* *      02350000


                               237 * ******************************************************************* *      02370000
                               238 *                                                                     *      02380000
                               239 *         THE ROUTINE MUST MEET THE FOLLOWING REQUIREMENTS            *      02390000
                               240 *                                                                     *      02400000
                               241 *      1. WHEN ENTERED FOR INPUT OR OUTPUT (NOT EXIT) IT MUST         *      02410000
                               242 *         ACCEPT THE STANDARD SPECIAL I/O LINKAGE PARAMETERS.         *      02420000
                               243 *                                                                     *      02430000
                               244 *      2. WHEN ENTERED VIA AN EXIT FROM CALCULATIONS IT MUST          *      02440000
                               245 *         ACCEPT THE STANDARD EXIT LINKAGE AND PARAMETERS.            *      02450000
                               246 *                                                                     *      02460000
                               247 *      3. IT MUST INDICATE END OF FILE BY PROVIDING THE CORRECT       *      02470000
                               248 *         COMPLETION CODE IN THE DTF.                                 *      02480000
                               249 *                                                                     *      02490000
                               250 *      4. IF A DIFFERENT AREA IS USED FOR THE ACTUAL INPUT OR         *      02500000
                               251 *         OUTPUT BUFFER THE DATA MUST BE MOVED TO OR FROM THE ADDRESS*      02510000
                               252 *         SUPPLIED IN THE DTF.                                        *      02520000
                               253 *                                                                     *      02530000
                               254 * ******************************************************************* *      02540000


    0000                       256       ORG   0                     SIGNALS START OF ROUTINE TEXT              02560000

                          0000 258 SUBR## EQU  *                     THIS IS THE ENTRY POINT TO THE RQUT.       02580000


                               260 *******      ROUTINE CODE IS PLACED HERE       *********                     02600000


                          0000 262       END   SUBR##                THIS INSURES PROPER LISTING FROM RPG       02620000
```

Replace these # signs with the characters identifying your subroutine.

Figure 29 (Part 4 of 4). Sample Coding for SPECIAL Device

Appendix E: Assembler Language Subroutine To COBOL or FORTRAN Linkage

This section describes standard linkage conventions for use between modules produced by the System/3 language translators: COBOL, FORTRAN, and Basic Assembler. Programmers using standard linkage conventions are able to code routines in the language most appropriate to the function being performed, with the assurance that effective and permanent communication has been established. Figure 30 illustrates the standard described on the following pages.

```
*
*       SAMPLE SYSTEM/3 LINKAGE -- MODULE A CALLS MODULE B
*
              EXTRN MODB
@XR1    EQU   X'01'
@XR2    EQU   X'02'
*
MODA    START X'0000'
*
*       INITIALIZE XR1 AND XR2 TO TEST SAVING
*
              L      XR1,@XR1
              L      XR2,@XR2
              B      MODB          CALL MODULE B
              DC     AL2(PLIST)
              HPL    X'6F',X'6F'   HALT 00 AFTER RETURN
*
*     PARAMETER LIST
*
PLIST       EQU    *
            DC     AL2 (SAVA)      ADDRESS OF SAVE AREA
            DC     AL2 (PARM1)     ADDRESS OF FIRST PARAMETER
            DC     AL2 (PARM2)     ADDRESS OF SECOND PARAMETER
            DC     XL1'00"
*
*     PARAMETERS
*
PARM1       EQU    EQU     *
            DC             CL5'FIRST'
PARM2       EQU            *
            DC             CL6'SECOND'
*
*      SAVE AREA
*
SAVA          DC     XL1'B0'      INDICATOR BYTE -- ASSEMBLER MAIN
              DC     CL6'MODE'    MODULE NAME
*
XR1           DC     CL2'R1'
XR2           DC     CL2'R2'
              END    MODA
```

Figure 30 (Part 1 of 2). Illustration of Standard Linkages

```
*
*       SAMPLE SYSTEM/3 LINKAGE -- MODULE A CALLS MODULE B
*
@XR1        EQU   X'01'
@XR2        EQU   X'02'
@ARR        EQU   X'08'
@IAR        EQU   X'10'
*
            ENTRY MODB
*
MODB        START X'0000'
*
            ST    SAVAR1,@XR1            SAVE CONTENTS OF XR1
            LA    SAVA,@XR1              XR1 WILL BE BASE FOR SAVE AREA
            USING SAVA,@XR1
            ST    SAVAR2(,@XR1),@XR2     SAVE CONTENTS OF XR2
            ST    SAVART(,@XR1),@ARR     SAVE CONTENTS OF ARR
            L     SAVART(,@XR1),@XR2     XR2 POINTS TO ADDRESS OF PARM
                                           LIST
            L     1(,@XR2),@XR2          XR2 POINTS TO PARAMETER LIST
            ALC   SAVART(,@XR1),TWO(,@XR1) SET RETURN POINT 2 PAST ARR.
*
*     BODY OF ROUTINE
*
            L     SAVAR2(,@XR1),@XR2     RESTORE XR2
            L     SAVAR1(,@XR1),@XR1     RESTORE XR1
            L     SAVART,@IAR            RETURN
*
*     SAVE AREA
*
SAVA        DC    XL1'30'                INDICATOR BYTE -- ASSEMBLER LANG
            DC    CL6'MODB'              MODULE NAME
SAVAR1      DC    XL2'00'                CONTENTS OF XR1 ON ENTRY TO THIS
*                                          MODULE
SAVAR2      DC    XL2'00'                CONTENTS OF XR2 ON ENTRY TO THIS
*                                          MODULE
SAVART      DC    AL2(00)                RETURN POINT
*
TWO         DC    IL2'2'
*
            END
```

Figure 30 (Part 2 of 2). Illustration of Standard Linkages

STANDARDS

In order to be standard, linkage must be accomplished as follows:

1. Each module must have a *save area* (Figure 31).

Byte	Bit	Description	Program
0	0	0=Not a main program 1=Main program	Subroutine Main program
	1-3	000=FORTRAN 001=COBOL 011=Basic Assembler	Subroutine Main program
	4-7	Reserved	
1-6		EBCDIC name, left justified	Subroutine Main program
7-8		Value of index register 1 (XR1) at entry	Subroutine
9-A		Value of index register 2 XR2) at entry	Subroutine
B-C		Return point in calling program	Subroutine

Note: Main program refers to the program with the highest level of control.

Figure 31. Save Area

2. Each module that calls another module must have one or more *parameter lists* (Figure 32).

Byte	Description
0-1	Address of save area in this program
2-3	Address of first parameter
(2N)-(2N+1)	Address of Nth parameter
(2N+2)	XL1'00' to indicate end of parameter list

Note: The first two bytes as well as the end-of-parameter-list indicator (XL1'00') must be present in all parameter lists. If no parameters are to be passed, the parameter list will be only three bytes in length. In this case, byte 3 will be 0 and the called program will indicate a parameter list length of 2.

Note: Addresses in parameter lists refer to the first byte (byte with the lowest address) of the item.

Figure 32. Parameter List

3. When control reaches a program entry point, the address recall register (ARR) must point to a 2-byte field containing the address of the first byte of the parameter list.

   The Basic Assembler language code to call a COBOL or FORTRAN subroutine would normally be as follows:

```
         EXTRN    SUBR
         B        SUBR
         DC       AL2(PARAMS)
RETNPT   EQU      *
```

   Note that the pointer to the parameter list points to the left byte of the save area address.

4. Normal return is accomplished by placing in the instruction address register (IAR) a value that is two larger than the contents of the ARR when the program was entered.

5. Index registers 1 and 2 (XR1 and XR2) must be saved upon entry in the called program's save area, and restored at exit.

6. The address recall register need not be restored, but the return address must be determined and placed in the called program's save area.

Along with the Basic Assembler, you will receive a sample program. By executing the sample program you can verify that the Basic Assembler is operational.

MODEL 10 AND MODEL 12 SAMPLE PROGRAM

This section describes the sample program and explains the operating procedures necessary for executing it. General operating procedures for the Basic Assembler are found in the *IBM System/3 Model 10 Disk System Operator's Guide,* GC21-7508, *IBM System/3 Model 12 Operator's Guide,* GC21-5144, and in Part II of this manual.

Program Description

The sample program is called Prime Number Test Program. The program reads a number from the console display data switches, tests to see if it is a prime number, and indicates the results of the test on the message display unit. If the number zero is tested, the program is terminated.

Three halt codes are used in this program to request input and indicate whether the number is prime. They are:

Halt Code	*Meaning*
EN	Enter a number to be tested.
IP	The number tested is prime.
NP	The number tested is not prime.

Figure 33 shows the OCL that assembles, link edits, and executes the sample program. Figure 34 shows the sample program statements.

IBM — IBM System/3 Basic Assembler Coding Form

```
// NOHALT
// LOAD $ASSEM,F1
// FILE NAME-$SOURCE,RETAIN-S,UNIT-R2,PACK-R2R2R2,TRACKS-5
// FILE NAME-$WORK,RETAIN-S,UNIT-F2,PACK-F2F2F2,TRACKS-2
// FILE NAME-$WORK2,RETAIN-S,UNIT-F1,PACK-F1F1F1,TRACKS-5
// COMPILE SOURCE-$ASSPL,UNIT-R1,OBJECT-R1
// RUN
// LOAD $OLINK,F1
// FILE NAME-$SOURCE,RETAIN-S,UNIT-R2,PACK-R2R2R2,TRACKS-10
// FILE NAME-$WORK,RETAIN-S,UNIT-F2,PACK-F2F2F2,TRACKS-10
// RUN
```

IBM — IBM System/3 Basic Assembler Coding Form

```
// PHASE NAME-$ASSPO
// OPTIONS MAP-XREF
// INCLUDE NAME-$ASSPR,UNIT-R1
// END
// HALT
// LOAD $ASSPO,F1
// RUN
```

NOTES:

1. Specifies the location of the assembler program.
2. Name of assembler sample program in the source library.
3. Specifies the source library with the sample program.
4. Library in which the output assembler object (R) module is stored.
5. Name given to the output assembler object (O) program.
6. Module name and object program name (R).
7. Specifies the object (O) program, stored on the Overlay Linkage Editor program pack by default.

If the system configuration does not include drive 2, references in the OCL to F2 and R2 must be changed to specify devices available on the system.

Figure 33. Model 10 and Model 12 Sample Program OCL

```
OPTIONS NODECK                                                                              0001
THE LIST OF OPTICNS USED DURING THIS ASSEMBLY IS--    NODECK,LIST,XREF,REL,OBJ



$ASSPR                              EXTERNAL SYMBCL LIST
SYMBOL    TYPE                                              VER 13.  MOD 00  01/30/76  PAGE  1
$ASSPR    MODULE



$ASSPR  PRIME NUMBER TEST PROGRAM
ERR LOC  OBJECT CODE       ADDR STMT SOURCE STATEMENT        VER 13.  MOD 00  01/30/76  PAGE  2
                                 2 *
                                 3 *   THIS PROGRAM READS A NUMBER FROM THE CONSOLE DISPLAY DATA SWITCHES, TESTS IT FOR
                                 4 * PRIMENESS, AND INDICATES THE RESULTS ON THE MESSAGE DISPLAY UNIT.
                                 5 *
                                 6 *   THERE ARE THREE HALT CODES USED IN THIS PROGRAM:
                                 7 *              HALT CODE   MEANING
                                 8 *                 EN       ENTER A NUMBER TO BE TESTED.  IF NUMBER ENTERED IS ZERO THE
                                 9 *                          PROGRAM TERMINATES.
                                10 *                 IP       NUMBER IS PRIME.
                                11 *                 NP       NUMBER IS NOT PRIME.
                                12 *
    0000                        13 $ASSPR START 0
                          0000  14        USING *,XR1                            ESTABLISH BASE REGISTER
    0000 C2 01 0000             15        LA    *,XR1                            LOAD BASE REGISTER
    0004 F0 7C 2F               16 BEGIN  HPL   X'2F',X'7C'                      'EN' HALT
    0007 70 00 78               17        SNS   SENSE(,XR1),0                    SENSE THE DATA SWITCHES
    000A 5D 01 78 70            18        CLC   SENSE(2,XR1),ZERO(,XR1)          TEST INDICATION TO QUIT
    000E F2 01 05               19        JNE   PREPAR                           NUMBER TO TEST
    0011 C0 87 0004             20        B     4                                GO TO END OF JOB
    0015 84               0015  21        DC    XL1'84'
                                22 *
                                23 *              PREPARE THE INPUT NUMBER
    0016 5D 01 78 76            24 PREPAR CLC   SENSE(2,XR1),THREE(,XR1)         TEST FOR ONE,TWO AND THREE
    001A F2 04 4C               25        JNH   PRIME#                           CALL ONE, TWO AND THREE PRIME
    001D 78 01 78               26        TBN   SENSE(,XR1),X'01'                TEST FOR EVEN
    0020 F2 90 40               27        JF    NPRIME                           EVEN, NOT PRIME
    0023 5C 01 7F 74            28        MVC   TEST#(2,XR1),TWO(,XR1)
    0027 5C 01 7B 78            29        MVC   END#+1(2,XR1),SENSE(,XR1)        DIVIDE INPUT BY TWO
    002B 7C 00 79               30        MVI   END#-1(,XR1),0                    TO USE FOR END TESTING
    002E 5E 02 7B 7B            31        ALC   END#+1(3,XR1),END#+1(,XR1)
    0032 5E 02 7B 7B            32        ALC   END#+1(3,XR1),END#+1(,XR1)
    0036 5E 02 7B 7B            33        ALC   END#+1(3,XR1),END#+1(,XR1)
    003A 5E 02 7B 7B            34        ALC   END#+1(3,XR1),END#+1(,XR1)
    003E 5E 02 7B 7B            35        ALC   END#+1(3,XR1),END#+1(,XR1)
    0042 5E 02 7B 7B            36        ALC   END#+1(3,XR1),END#+1(,XR1)
    0046 5E 02 7B 7B            37        ALC   END#+1(3,XR1),END#+1(,XR1)
                                38 *
                                39 *              MAIN TEST LOOP
    004A 5E 01 7F 72            40 LCOPST ALC   TEST#(2,XR1),ONE(,XR1)           INCREMENT TEST
    004E 5D 01 7F 7A            41        CLC   TEST#(2,XR1),END#(,XR1)          TEST FOR COMPLETE
    0052 F2 84 14               42        JH    PRIME#                           COMPLETE, CALL IT PRIME
    0055 5C 01 7D 78            43        MVC   TEMPAR(2,XR1),SENSE(,XR1)        MAKE COPY AND
    0059 5F 01 7D 7F            44 SUBTR  SLC   TEMPAR(2,XR1),TEST#(,XR1)         FIND REMAINDER
    005D D0 84 59               45        BP    SUBTR(,XR1)                       BY SUBTRACTING
    0060 D0 01 4A               46        BNZ   LCOPST(,XR1)                     REMAINDER NOT ZERO
                                47 *
                                48 *              NUMBER NOT PRIME
    0063 F0 2F 3E               49 NPRIME HPL   X'3E',X'2F'                      NOT PRIME (NP) HALT
    0066 D0 87 04               50        B     BEGIN(,XR1)                      GO BACK TO BEGINING
                                51 *
                                52 *              NUMBER IS PRIME
    0069 F0 03 3E               53 PRIME# HPL   X'3E',X'03'                      IS PRIME (IP) HALT
    006C D0 87 04               54        B     BEGIN(,XR1)                      GO BACK TO BEGINING
```

Figure 34 (Part 1 of 2). Listing of Statements in Model 10 and Model 12 Basic Assembler Sample Program

```
$ASSPR  PRIME NUMBER TEST PROGRAM

ERR LOC  OBJECT CODE       ADDR STMT SOURCE STATEMENT          VER 13.  MOD 00   01/30/76   PAGE  3

                                56 *                                                                 0C57
                                57 *               CATA AREA                                         0058
    006F 0000             C070  58 ZERO   DC       IL2'0'                      BINARY ZERO           0059
    0071 0001             0072  59 ONE    DC       XL2'0001'                          CNE            0C6C
    0073 0002             0074  60 TWC    CC       BL2'00000010'                      TWO            0061
    0075 0003             0076  61 THREE  DC       AL2(3)                             THREE          CC62
    0077                  0078  62 SENSE  DS       CL2                                               0063
    0079                  007A  63 END#   DS       CL2                                               0064
    007B                  007B  64        DS       CL1                                               0065
    007C                  007D  65 TEMPAR DS       CL2                                               0066
    007E                  007F  66 TEST#  DS       CL2                                               0067
                          0001  67 XR1    EQU      1                           BASE REGISTER         0068
                          0000  68        END      $ASSPR                                            0C69

TOTAL STATEMENTS IN ERROR IN THIS ASSEMBLY =     0
```

```
$ASSPR                              CROSS REFERENCE

SYMBOL  LEN VALUE DEFN   REFERENCES                            VER 13.  MOD 00   01/30/76   PAGE  4

$ASSPR  001  0000 0013   0068
BEGIN   003  0004 0016   0050  0054
END#    002  007A 0063   C029* 0030* 0031  0031* 0032  0032* 0033  0033* 0034  0034* 0035  0035*
                         0036  0036* C037  CC37* 0041
LOOPST  004  004A 0040   0046
NPRIME  003  0063 CC49   0027
ONE     002  0072 0059   0040
PREPAR  004  0016 0024   0019
PRIME#  003  0069 0053   0025  0042
SENSE   002  0078 0062   0017* 0018  C024  0026  0029  0043
SUBTR   004  0059 0C44   0045
TEMPAR  002  007D 0065   C043* C044*
TEST#   002  007F 0066   0028* 0040* 0041  0044
THREE   002  0076 0061   C024
TWO     002  0074 0060   0028
XR1     0C1  0001 0067   0014  0015* 0017  0018  0018  0024  0024  0026  0028  0028  0C29  0029
                         0030  0031  0031  CC32  0032  0033  0033  0034  0034  0035  0035  0036
                         0036  0037  C037  CC40  0C4C  CC41  CC41  0043  0043  0044  0044  0045
                         0046  0050  0054
ZERO    002  0070 CC58   0018

TOTAL STATEMENTS IN ERROR IN THIS ASSEMBLY =     0

OL105 I  THE CODE LENGTH OF $ASSPR IS   128 DECIMAL.
OL103 I  TCTAL NUMBER OF LIBRARY SECTCRS RECUIRED IS    2
         NAME-$ASSPR,PACK-R1R1R1,UNIT-R1,RETAIN-T,LIBRARY-R,CATEGORY-000
```

Figure 34 (Part 2 of 2). Listing of Statements in Model 10 and Model 12 Basic Assembler Sample Program

MODEL 15 SAMPLE PROGRAM

This section describes the sample program and explains the operating procedures necessary for executing it. General operating procedures for the Basic Assembler are found in the *IBM System/3 Model 15 Operator's Guide*, GC21-5075 and in Part II of this manual.

Program Description

The sample program is called System Input Device List Program. The program reads records from the system input device and lists them on the system printer. Statements are read and listed until one of the delimiters (/*,/&, or /.) is encountered. If the delimiter is /*, another file can be listed under operator control.

There are three messages displayed by this program:

Message	*Meaning*
EOF ON SYSIN	End of file encountered on the system input device. More files can be printed if the EOF condition is caused by /*. The operator replies P to print another file or C to cancel.
PRINTER ERROR	A permanent printer error has occurred. The program issues the message and then goes to end of job. (The message is displayed and then removed when end of job is reached. However, the message is in the system history area and may be displayed from there.)
SYSIN ERROR	A permanent system input device error has occurred. The program issues the message and then goes to end of job. (The message is displayed and then removed when end of job is reached. However, the message is in the system history area and may be displayed from there.)

The sample program uses Model 15 macros and therefore the assembly step must be preceded by a macro processor step.

Figure 35 shows the OCL that assembles, link edits, and executes the sample program. Figure 36 shows the sample program statements.

IBM

IBM System/3 Basic Assembler Coding Form

```
// ASAMP JOB
// LOAD $MPXDV,F1
// FILE NAME-$SOURCE,RETAIN-T,UNIT-R2,PACK-R2R2R2,TRACKS-6
// COMPILE SOURCE-$ASSPL,UNIT-F1
// RUN



// LOAD $ASSEM,F1
// SWITCH 1XXXXXXX
// FILE NAME-$WORK,RETAIN-S,UNIT-R2,PACK-R2R2R2,TRACKS-2
// FILE NAME-$WORK2,RETAIN-S,UNIT-D1,PACK-D1D1D1,TRACKS-10
// FILE NAME-$SOURCE,RETAIN-S,UNIT-R2,PACK-R2R2R2
// COMPILE OBJECT-R1
```

IBM

IBM System/3 Basic Assembler Coding Form

```
// RUN
// LOAD $OLINK,F1
// FILE NAME-$WORK,RETAIN-S,UNIT-D1,PACK-D1D1D1,TRACKS-10
// FILE NAME-$SOURCE,RETAIN-S,UNIT-R2,PACK-R2R2R2,TRACKS-10
// RUN
// PHASE NAME-$ASSPO
// OPTIONS MAP-XREF
// INCLUDE NAME-$ASSPR,UNIT-R1
// INCLUDE NAME-$$LPRT,UNIT-F1
// END
// LOAD $ASSPO,F1
// RUN
```

Notes:

1. Specifies the program pack.
2. Name of the assembler sample program in the source library.
3. Library in which the output assembler object (R) module is stored.
4. Name given to the output assembler object (O) program.
5. Module name and object program name (R).
6. Specifies the system pack.

If the system configuration does not include the 5444 drive 2 or the 5445 drive 1, references in the OCL to R2 and D1 must be changed to specify devices available on the system.

Figure 35. Model 15 Sample Program OCL

```
OPTIONS NODECK                    OBJECT TO LIBRARY ONLY          00010000
THE LIST OF OPTIONS USED DURING THIS ASSEMBLY IS--   NODECK,LIST,XREF,REL,OBJ


$ASSPR                            EXTERNAL SYMBOL LIST

SYMBOL    TYPE                                         VER 01, MOD 00  11-09-73  PAGE   1

$ASSPR    MODULE
$$LPRT    EXTRN


$ASSPR

ERR LOC  OBJECT CODE      ADDR STMT SOURCE STATEMENT          VER 01, MOD 00  11-09-73  PAGE   2

                                   1         ICTL  1,71                                                                00020000
                                   2         ISEQ  73,80                                                               00030000
                                   3         PRINT NOGEN,NODATA                                                        00040000


$ASSPR SYSTEM INPUT DEVICE (SYSIN) LIST PROGRAM

ERR LOC  OBJECT CODE      ADDR STMT SOURCE STATEMENT          VER 01, MOD 00  11-09-73  PAGE   3

                                   5 *    THIS PROGRAM READS A FILE FROM THE SYSTEM INPUT DEVICE AND LISTS     00060000
                                   6 *     IT ON THE PRINTER.                                                  00070000
                                   7 *                                                                         00080000
                                   8 *    THERE ARE THREE MESSAGES ISSUED BY THIS PROGRAM:                     00090000
                                   9 *     MESSAGE          TYPE  MEANING                                      00100000
                                  10 *     'EOF ON SYSIN'   WTOR  END OF FILE ENCOUNTERED ON SYSIN.             00110000
                                  11 *                             MORE FILES MAY BE PRINTED IF THE             00120000
                                  12 *                             EOF CONDITION IS CAUSED BY A '/*'.           00130000
                                  13 *                             THE OPERATOR REPLYS TO THIS MESSAGE          00140000
                                  14 *                             ARE 'P' TO PRINT ANOTHER FILE AND            00150000
                                  15 *                             'C' TO CANCEL AND GO TO EOJ.                 00160000
                                  16 *     'PRINTER ERROR' WTO   THERE HAS BEEN A PERMANENT PRINTER             00170000
                                  17 *                             ERROR.  THE PROGRAM ISSUES THE               00180000
                                  18 *                             MESSAGE AND GOES TO END OF JOB.              00190000
                                  19 *     'SYSIN ERROR'   WTO   THERE HAS BEEN A PERMANENT SYSIN               00200000
                                  20 *                             ERROR.  THE PROGRAM ISSUES THE               00210000
                                  21 *                             MESSAGE AND GOES TO END OF JOB.              00220000

    4000                          23 $ASSPR START X'4000'                                                       00240000
                          0001    24        EXTRN $$LPRT                   PRINTER DATA MANAGEMENT              00250000
                          408C    25        USING BASE,BRG                 ESTABLISH A BASE REGISTER            00260000
    4000 C2 01 408C               26        LA    BASE,BRG                  FOR THE DATA AREAS                  00270000

                                  28 * PREPARE THE PRINTER FILE FOR USE                                         00290000
    4004 D2 02 07                 29        LA    PRNDTF(,BRG),$DTF                                             00300000
                                  30 *      $ALOC                          ALLOCATE PRINTER FILE                00310000
                                  33 *      $OPEN                          OPEN PRINTER FILE                    00320000
    400F BC 01 13                 36        MVI   $DFSPA(,$DTF),1          SET FOR SINGLE SPACE                 00330000
    4012 BC 40 0F                 37        MVI   $DFOPC(,$DTF),$OCPRT     SET OP-CODE TO PRINT                 00340000
    4015 7C 01 00                 38        MVI   SYSINL+$SRFCT(,BRG),$SRRDF SET SYSIN OP-CODE FOR 1ST BUFF     00350000

                                  40 * PREPARE TO PRINT A NEW FILE                                              00370000
    4018 7C 01 17                 41 FILES  MVI   PRNDTF+$DFSKB(,BRG),1    SET TO SKIP BEFORE FIRST PRINT       00380000

                                  43 * READ FROM SYSIN AND PRINT UNTIL END OF FILE                              00400000
    401B D2 02 00                 44 FILEL  LA    SYSINL(,BRG),SYS                                              00410000
                                  45 *      $READ OPC-N                    READ FROM SYSIN                      00420000
    4022 BD 50 00                 49        CLI   $SRFCT(,SYS),$SREOF      TEST FOR EOF   ('/*','/&','/.')      00430000
    4025 F2 81 30                 50        JE    EOF                                                           00440000
    4028 BD 80 00                 51        CLI   $SRFCT(,SYS),$SREOJ      TEST FOR EOJ   ('/&','/.')           00450000
    402B F2 81 53                 52        JE    EOJ                                                           00460000
    402E BD 60 00                 53        CLI   $SRFCT(,SYS),$SRERR      TEST FOR SYSIN ERROR                 00470000
    4031 F2 81 3C                 54        JE    SYSER                                                         00480000
    4034 BC 00 00                 55        MVI   $SRFCT(,SYS),$SRRDD      SET FOR NEXT SYSIN READ              00490000
    4037 6C 01 14 04              56        MVC   PRNDTF+$DFLRA(2,BRG),$SRBF2(,SYS) POINT TO CURRENT RECORD     00500000
    403B D2 02 07                 57        LA    PRNDTF(,BRG),$DTF                                             00510000
                                  58 *      $PUTP DEV-1403                 PRINT THE CURRENT RECORD             00520000
    4042 BD 41 0E                 60        CLI   $DFCMP(,$DTF),$CPPER     TEST FOR PRINTER ERROR               00530000
    4045 F2 81 32                 61        JE    PRNERR                                                        00540000
    4048 BC 00 10                 62        MVI   $DFSKB(,$DTF),0          SET FOR NO SKIP BEFORE               00550000
    404B BD 48 0E                 63        CLI   $DFCMP(,$DTF),$CPOVF     TEST FOR PAGE OVERFLOW               00560000
    404E F2 01 03                 64        JNE   NOSKIP                                                        00570000
    4051 BC 01 10                 65        MVI   $DFSKB(,$DTF),1          SET FOR SKIP TO LINE ONE             00580000
    4054 C0 87 401B               66 NOSKIP B     FILEL                                                         00590000
```

Figure 36 (Part 1 of 4). Listing of Statements in Model 15 Basic Assembler Sample Program.

```
$ASSPR SYSTEM INPUT DEVICE (SYSIN) LIST PROGRAM

ERR LOC  OBJECT CODE       ADDR STMT SOURCE STATEMENT           VER 01, MOD 00  11-09-73  PAGE    4

                                  68 * END OF FILE ON SYSIN                                                  00610000
     4058 D2 02 28                69 EOF     LA     EOFMSG(,BRG),LOG                                         00620000
                                  70 *       $LOG                            WTOR EOF MESSAGE                00630000
     405F 7D C3 37                74         CLI    REPLY(,BRG),C'C'         OPERATOR SAY CANCEL             00640000
     4062 F2 81 1C                75         JE     EOJ                                                      00650000
     4065 7D D7 37                76         CLI    REPLY(,BRG),C'P'         OPERATOR SAY PRINT ANOTHER      00660000
     4068 C0 81 4018              77         BE     FILES                                                    00670000
     406C C0 87 4058              78         B      EOF                      INVALID REPLY, TRY AGAIN        00680000

                                  80 * ERROR ON SYSIN                                                        00700000
     4070 D2 02 38                81 SYSER  LA      SERMSG(,BRG),LOG                                         00710000
                                  82 *       $LOG                            WTO SYSIN ERROR MESSAGE         00720000
     4077 F2 87 07                86         J      EOJ                      GO TO EOJ                       00730000

                                  88 * ERROR ON PRINTER                                                      00750000
     407A D2 02 44                89 PRNERR LA      PERMSG(,BRG),LOG                                         00760000
                                  90 *       $LOG                            WTO PRINTER ERROR MESSAGE       00770000

                                  95 * END OF JOB ROUTINE                                                    00790000
                             4081 96 EOJ     EQU    *                                                        00800000
     4081 D2 02 07                97         LA     PRNDTF(,BRG),$DTF                                        00810000
                                  98 *       $CLOS                           CLOSE PRINTER FILE              00820000
                                 101 *       $EOJ                            GO TO EOJ                       00830000
```

```
$ASSPR SYSTEM INPUT DEVICE (SYSIN) LIST PROGRAM

ERR LOC  OBJECT CODE       ADDR STMT SOURCE STATEMENT           VER 01, MOD 00  11-09-73  PAGE    5

                                 105 * CONSTANTS AND DATA AREAS                                              00850000
                            408C 106 BASE    EQU    *                        BASE REGISTER ADDRESS           00860000

                                 108 * SYSIN TABLES                                                          00880000
                                 109 *YSINL $RLST BUF1-BUFFR1,BUF2-BUFFR2,   SYSIN PARAMETER LIST           X00890000
                                 110 *              WORK-WORKAR                                              00900000
                                 116 *       $RLSD                           SYSIN EQUATES                   00910000

                                 133 * PRINT FILE TABLES                                                     00930000
                                 134 *RNDTF $DTFP DEV-1403,RCAD-0,IOBA-PRNIOB, PRINT FILE DTF               X00940000
                                 135 *              IOAA-PRNBUF,RECL-96,                                    X00950000
                                 136 *              OVFL-60,PAGE-66                                          00960000
                                 160 *       $DTFO D1403-Y                   PRINTER DTF DISPLACEMENTS       00970000

                                 223 * SYSTEM LOG TABLES                                                     00990000
                                 224 *OFMSG $LWTO COMP-AS,HALT-AM,SUBH-PG,TLEN-12, SYSIN EOF WTOR           X01000000
                                 225 *              TADR-EOFMGC,REPLY-Y,RLEN-1,RADR-REPLY                    01010000
     40C3 E7                40C3 238 REPLY   DC     CL1'X'                   WTOR REPLY                      01020000
                                 239 *ERMSG $LWTO COMP-AS,HALT-AM,SUBH-PG,TLEN-11, SYSIN ERROR WTO          X01030000
                                 240 *              TADR-SERMGC                                              01040000
                                 251 *ERMSG $LWTO COMP-AS,HALT-AM,SUBH-PG,TLEN-13, PRINTER ERROR WTO        X01050000
                                 252 *              TADR-PERMGC                                              01060000
                            40DC 263 EOFMGC EQU     *                                                        01070000
     40DC C5D6C640D6D540E2 40E7  264         DC     CL12'EOF ON SYSIN'                                       01080000
                            40E8 265 SERMGC EQU     *                                                        01090000
     40E8 E2E8E2C9D540C5D9 40F2  266         DC     CL11'SYSIN ERROR'                                        01100000
                            40F3 267 PERMGC EQU     *                                                        01110000
     40F3 D7D9C9D5E3C5D940 40FF  268         DC     CL13'PRINTER ERROR'                                      01120000

                                 270 * SYSIN BUFFER AND WORK AREAS                                           01140000
     4100                        271         ORG    *,128                    ORG TO REQUIRED BOUNDARY        01150000
                            4100 272 BUFFR1 EQU     *                        BUFFER ONE                      01160000
     4100 0000000000000000 417F  273         DC     XL128'0'                                                 01170000
                            4180 274 BUFFR2 EQU     *                        BUFFER TWO                      01180000
     4180 0000000000000000 41FF  275         DC     XL128'0'                                                 01190000
                            4200 276 WORKAR EQU     *                        WORK AREA                       01200000
     4200 0000000000000000 422E  277         DC     XL47'0'                                                  01210000

                                 279 * PRINTER BUFFER AND WORK AREAS                                         01230000
     427C                        280         ORG    *,256,X'7C'              ORG TO REQUIRED BOUNDARY        01240000
                            427C 281 PRNBUF EQU     *                        PRINTER BUFFER                  01250000
     427C 4040404040404040 4305  282         DC     CL138' '                                                 01260000
                            4306 283 PRNIOB EQU     *                        PRINTER IOB                     01270000
     4306 0000000000000000 4337  284         DC     XL50'0'                                                  01280000

                                 286 * REGISTER LABELS                                                       01300000
                            0001 287 BRG     EQU    1                        BASE REGISTER                   01310000
                            0002 288 SYS     EQU    2                        SYSIN PARAMETER LIST POINTER    01320000
                            0002 289 LOG     EQU    2                        SYSLOG PARAMETER LIST POINTER   01330000
                            4000 290         END    $ASSPR                                                   01340000

TOTAL STATEMENTS IN ERROR IN THIS ASSEMBLY--      0

TOTAL SEQUENCE ERRORS IN THIS ASSEMBLY--          0
```

Figure 36 (Part 2 of 4). Listing of Statements in Model 15 Basic Assembler Sample Program.

```
$ASSPR                                CROSS REFERENCE

SYMBOL  LEN VALUE DEFN   REFERENCES                                             VER 01, MOD 00  11-09-73  PAGE   6

$$LPRT  001  0001 0024   0059
$ASSPR  001  4000 0023   0290
$A1CDI  001  0010 0193
$A1DAT  001  0001 0198
$A1H56  001  0002 0196
$A1INT  001  0004 0195
$A1MFM  001  0008 0194
$A1PCH  001  0020 0192
$A1PRT  001  0040 0191
$A1PR2  001  0001 0197
$A1RD   001  0080 0190
$A2ALL  001  0040 0203
$A2AMP  001  0004 0208
$A2EOF  001  0008 0206
$A2HUC  001  0002 0207
$A2IND  001  0080 0202
$A2MBF  001  0010 0205
$A2OPN  001  0001 0209
$A2SIN  001  0020 0204
$CPCND  001  0010 0214
$CPEOF  001  0042 0217
$CPOVF  001  0048 0213   0063
$CPPER  001  0041 0216   0060
$CPSUC  001  0040 0215
$DFARR  001  0009 0168
$DFAT1  001  0002 0164
$DFAT2  001  0003 0165
$DFCHA  001  0005 0166
$DFCHB  001  0007 0167
$DFCMP  001  000E 0171   0060  0063
$DFDEV  001  0000 0162
$DFLP   001  001D 0183
$DFLRA  001  000D 0170   0056*
$DFMSK  001  001F 0185
$DFOPC  001  000F 0172   0037*
$DFOVF  001  001C 0182
$DFPGS  001  0020 0186
$DFPIB  001  0017 0179
$DFPIO  001  0019 0180
$DFPOS  001  001E 0184
$DFPQ   001  0014 0177
$DFPR   001  0015 0178
$DFPRL  001  001B 0181
$DFSKA  001  0012 0175
$DFSKB  001  0010 0173   0041* 0062* 0065*
$DFSPA  001  0013 0176   0036*
$DFSPB  001  0011 0174
$DFUPS  001  0001 0163
$DFXRS  001  0008 0169
$DTF    001  0002 0161   0029* 0036  0037  0057* 0060  0062  0063  0065  0097*
$OCPRT  001  0040 0221   0037
$SRBF1  001  0002 0118
$SRBF2  001  0004 0119   0056
$SREOF  001  0050 0129   0049
$SREOJ  001  0080 0131   0051
$SRERR  001  0060 0130   0053
```

Figure 36 (Part 3 of 4). Listing of Statements in Model 15 Basic Assembler Sample Program.

```
$ASSPR                                CROSS REFERENCE

SYMBOL  LEN VALUE DEFN   REFERENCES                                            VER 01, MOD 00   11-09-73   PAGE    7

$SRFCT  001  0000 0117   0038* 0049  0051  0053  0055*
$SRNOM  001  0040 0128
$SRRD   001  0009 0126
$SRRDD  001  0000 0123   0055
$SRRDF  001  0001 0124   0038
$SRRDL  001  0002 0125
$SRWRK  001  0006 0120
BASE    001  408C 0106   0025  0026
BRG     001  0001 0287   0025  0026* 0029  0038  0041  0044  0056  0057  0069  0074  0076  0081
                         0089  0097
BUFFR1  001  4100 0272   0113
BUFFR2  001  4180 0274   0114
EOF     003  4058 0069   0050  0078
EOFMGC  001  40DC 0263   0235
EOFMSG  001  4084 0227   0069
EOJ     001  4081 0096   0052  0075  0086
FILEL   003  401B 0044   0066
FILES   003  4018 0041   0077
LOG     001  0002 0289   0069* 0081* 0089*
NOSKIP  004  4054 0066   0064
PERMGC  001  40F3 0267   0262
PERMSG  001  40D0 0254   0089
PRNBUF  001  427C 0281   0153
PRNDTF  001  4093 0137   0029  0041* 0056* 0057  0097
PRNERR  003  407A 0089   0061
PRNIOB  001  4306 0283   0152
REPLY   001  40C3 0238   0074  0076  0237
SERMGC  001  40E8 0265   0250
SERMSG  001  40C4 0242   0081
SYS     001  0002 0288   0044* 0049  0051  0053  0055  0056
SYSER   003  4070 0081   0054
SYSINL  001  408C 0111   0038* 0044
WORKAR  001  4200 0276   0115

TOTAL STATEMENTS IN ERROR IN THIS ASSEMBLY--       0

TOTAL SEQUENCE ERRORS IN THIS ASSEMBLY--           0


OL105 I   THE CODE LENGTH OF $ASSPR IS    824 DECIMAL.
OL103 I   TOTAL NUMBER OF LIBRARY SECTORS REQUIRED IS     5
          NAME-$ASSPR,PACK-R1R1R1,UNIT-R1,RETAIN-T,LIBRARY-R,CATEGORY-000
```

Figure 36 (Part 4 of 4). Listing of Statements in Model 15 Basic Assembler Sample Program.

Appendix G: IBM 1255 Magnetic Character Reader Support (Models 12 and 15 Only)

Support is provided by the following IBM-supplied subroutines:

- SUBR07 – 1255 (Model 15 only)
- SUBR08 – 1255 (Model 12 and Model 15)
- SUBR09 – 1419 (Model 12 and Model 15)

For detailed information concerning this support, see the *IBM System/3 Models 12 and 15 1255 and 1419 Magnetic Character Reader Reference and Program Logic Manual*, GC21-5132.

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